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VAN PATTEN WOODS POTENTIAL WETLAND COMPENSATION SITE:
FINAL HYDROGEOLOGIC CHARACTERIZATION REPORT

Illinois Route 173, near Rosecrans
Lake County, Illinois
(Federal Aid Project 303)

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James J. Miner
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615 East Peabody Drive
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Submitted Under Contract No. AE89005 to
Illinois Department of Transportation
Bureau of Design and Environment, Wetlands Unit
2300 South Dirksen Parkway
Springfield, IL 62764

April 15, 1997

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EXECUTIVE SUMMARY

The hydrogeology of a potential wetland compensation site at Van Patten Woods was studied between August 1994 and December 1996. The site is located in a Lake County Forest Preserve near Rosecrans, Illinois. The study area includes the compensation site and an adjacent sedge meadow to the north. The sedge meadow was studied to determine what water sources were available for use in the compensation site. The sedge meadow and the compensation site are underlain by a north–south trending body of sand and gravel, which slopes upward in elevation from the sedge meadow on the north into the compensation site on the south. The sand and gravel body receives surface-water runoff from a large area underlain by glacial till to the east of the site, and ground-water discharge from surrounding upland areas. The sand and gravel unit is bounded by less permeable units to the east, west, and below, but is hydrologically unconfined upward toward land surface so that when the unit is saturated, surface water appears in the sedge meadow. Because above-average precipitation was received in spring of 1995, wetland hydrology is shown by water levels in two wells outside the sedge meadow in the compensation site. However, these areas lack a dominance of hydrophytic vegetation and would not likely show wetland hydrology in years with average precipitation. The primary hydrogeologic difference between the sedge meadow and the compensation site is elevation, so it may be possible to create an environment similar to the sedge meadow by lowering land surface in the compensation site to intersect the water table. Excavation of about 0.50 to 0.75 meters would be necessary to replicate the deeper inundation observed in the sedge meadow. In September 1995, IDOT excavated the compensation site using preliminary data provided by ISGS in the Interim Report for this site submitted in August 1995. The preliminary recommendations were similar to those presented in this Final Report, but were based only on data collected through July 1995. In spring 1996, surface water ponded to a depth of about 0.5 m in the excavation prior to drying up in midsummer. This pattern is similar to that observed in the sedge meadow.

The text and illustrations in this document have received only limited scientific and editorial review.

CONTENTS

FIGURES

TABLES

INTRODUCTION

This report was prepared by the Illinois State Geological Survey (ISGS) to provide the Illinois Department of Transportation (IDOT) with final conclusions regarding the hydrogeologic conditions in a portion of the Van Patten Woods Forest Preserve (fig. 1). The study area described below contains a proposed wetland compensation site and an adjacent natural sedge meadow wetland to the north (fig. 2).

The purpose of this report is to identify the hydrogeologic conditions present in the proposed compensation site and the sedge meadow, and to compare any differences in order to assist in the creation or restoration of wetlands in the compensation site. This report includes ground- and surface-water level data collected from August 1994 through December 1996. This report supersedes the Interim Report provided to IDOT in August 1995 (Miner and Fucciolo 1995).

In September 1995, IDOT excavated in the compensation area based on preliminary recommendations from the Interim Report. Water-level monitoring has continued in order to determine the effects of the construction activities and to confirm the preliminary conclusions made in the Interim Report. A Final Monitoring Report that describes the hydrogeologic conditions after construction will be submitted at the end of a five-year monitoring period (September 2000), unless otherwise directed by IDOT.

The study area (fig. 1) is located in S 1/2, Section 10 and NW 1/4, Section 15, T46N, R11E, approximately 1 kilometer (km) northeast of the intersection of U.S. Route 41 and Illinois Route 173 near Rosecrans, Lake County, Illinois. The site is located within the Des Plaines River valley in the Van Patten Woods Forest Preserve, and is managed by the Lake County Forest Preserve District.

METHODS

The geology of the study area was characterized by drilling 13 borings (fig. 2) using various methods as required by site conditions. Six borings (1–6) were made in the compensation site using a Mobile B-30S drill rig, which collected a continuous, 10-centimeter (cm) diameter core using a 1.5-meter (m) long split-spoon sampler. Within and adjacent to the sedge meadow to the north, seven borings (7–13) were made using a hand auger 7.5 cm in diameter. Geologic logs for each boring are shown in Appendix A. Cross sections are included in Appendix A that indicate each unit of sediment encountered. Lines of cross-section are shown in figure 3.

The hydrology of the site was characterized by measuring ground-water levels in monitoring wells (fig. 3) installed at various depths in selected geologic borings. Monitoring wells 1 through 6 (U and L) (upper and lower screened intervals) were installed through the hollow-stem auger of the Mobile drill rig. Monitoring wells 1 through 12 (S) (soil-zone screened interval) and 7 through 14 (S and L) were installed in open boreholes made using a hand auger. Well 14S was installed in August 1995 to enable installation of a water-level recording device (RDS); no log for this boring was prepared for this report. Surface-water levels were measured at stage gauges located within the sedge meadow (A) and in the Des Plaines River (B) (fig. 3). The wells were monitored monthly beginning in August 1994, and weekly from March 1995 through August 1996. Water-level elevations and depths to water in wells and on the stage gauges are reported in Appendix B. All values reported were rounded to the nearest centimeter.

Well casing and screen for wells 1 through 6 (U and L), 12 (L), 13 (L), and 14(S) consisted of 5.1-cm diameter PVC pipe; all other wells were constructed of 2.5-cm diameter PVC pipe. Well screens were between 0.30 and 0.75 m in length, and contained slots 0.25 millimeters (mm) wide. Well screens were packed with quartz sand 0.5 to 1.0 mm in diameter. Borings were then backfilled to land surface with bentonite. Wells were developed by surging the wells with

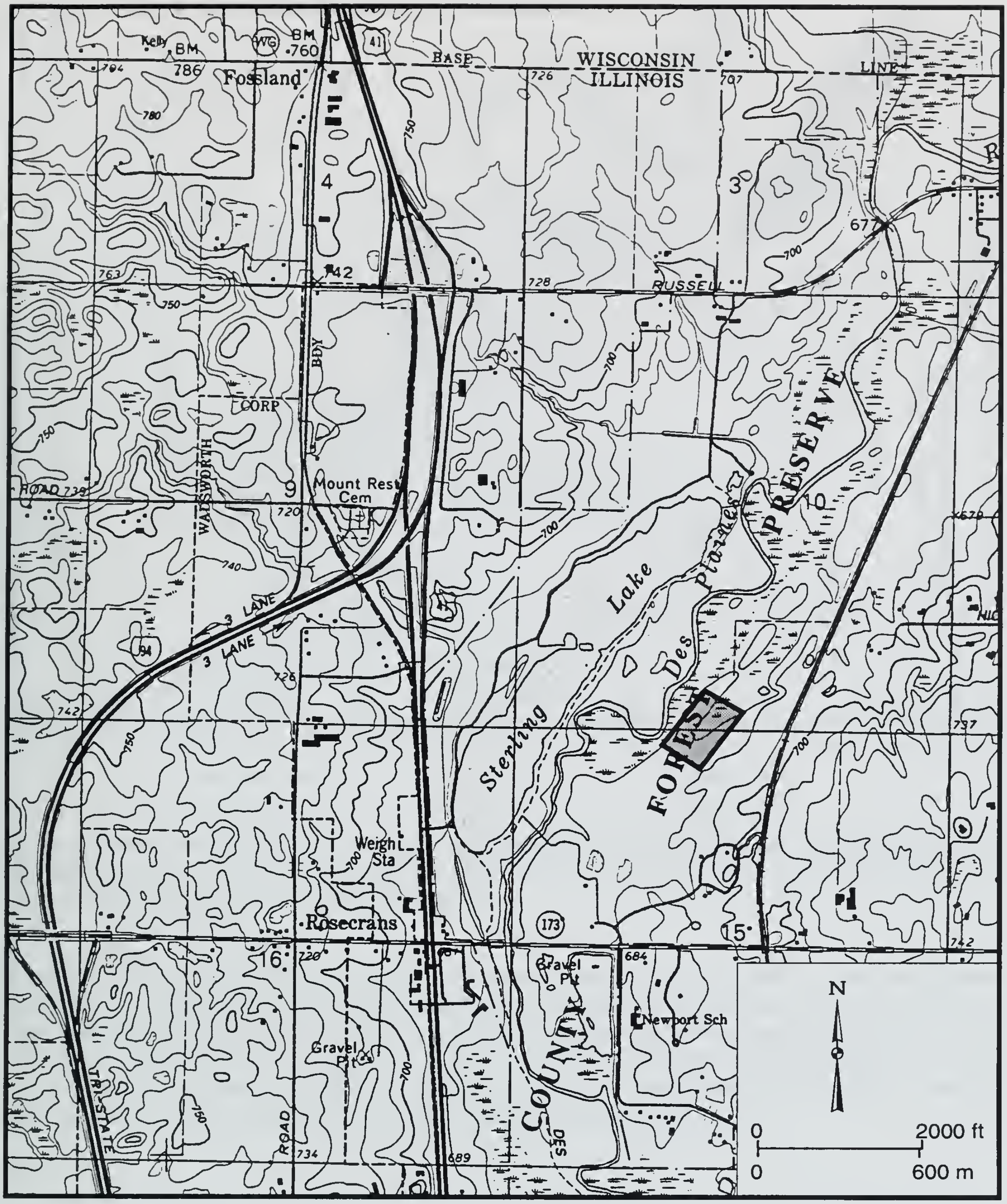

Figure 1 Location map showing the study area (shaded) on the Wadsworth, IL–WI, 7.5-minute topographic map (U.S. Geological Survey 1993). Contour interval is 10 ft (3 m).

a surge block then pumping the wells with a peristaltic pump until clear water was obtained or until dry. Cross sections showing the location of the screened interval of each well are shown in Appendix A. Appendix C lists all well-construction measurements. The relative elevations of the stage gauges and wells were determined by leveling to third-order accuracy using a Sokkia B-1 automatic level and a fiberglass extending rod.

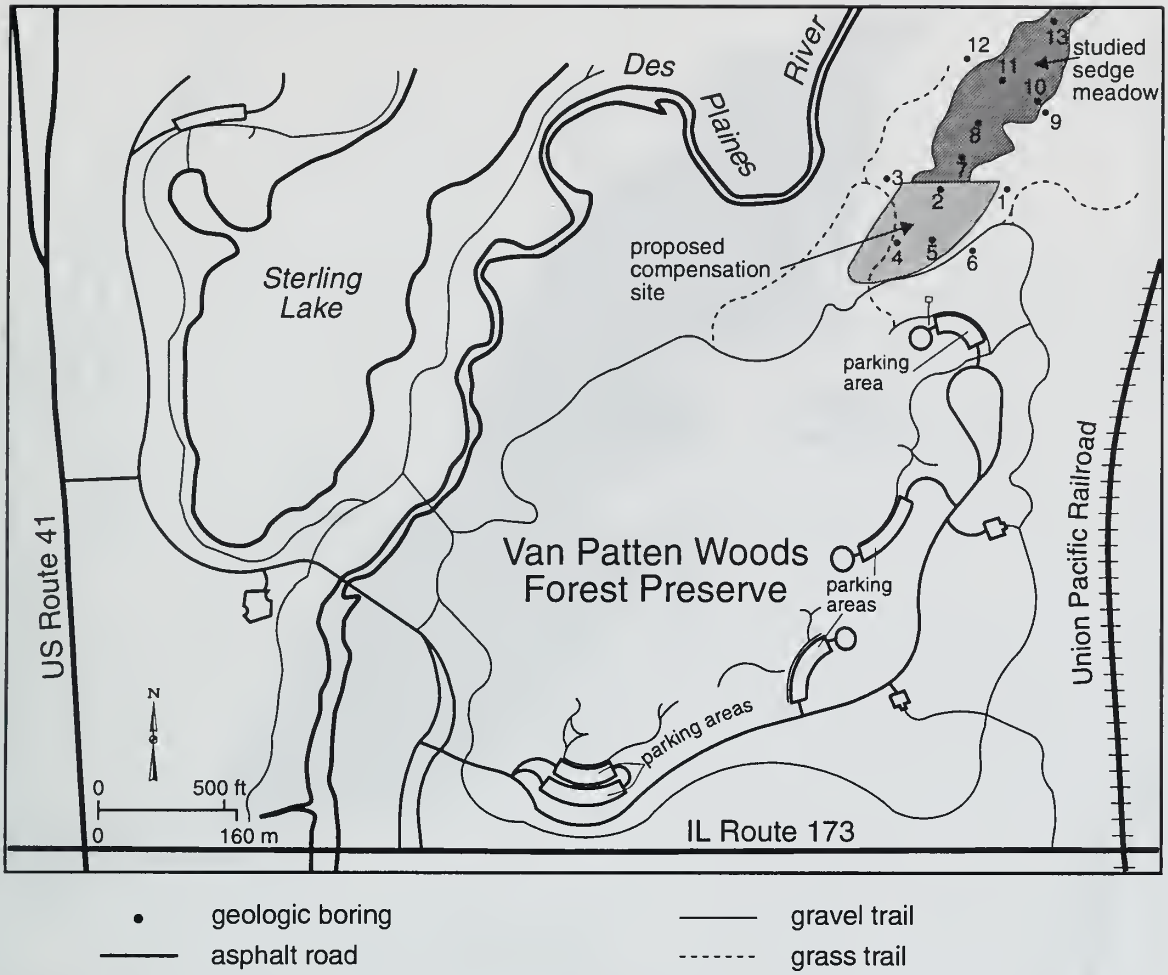

Figure 2 Site map showing the proposed compensation site, the studied sedge meadow, and the locations of geologic borings made in this study. Map based on USGS (1993) and a Lake County Forest Preserve map of Van Patten Woods (date unknown).

A benchmark was established on site at an arbitrary elevation of 100.000 m. The benchmark is a chiseled square located on the southeast corner of the concrete pad supporting an outhouse approximately 50 m south of the site. All elevations listed in this report are relative to the benchmark listed above. In April 1996, IDOT surveyed this benchmark and determined that it has an absolute elevation of 207.400 m (NGVD, 1929). To convert relative elevations listed in this report to absolute elevations, it is necessary to add 107.400 m.

GEOLOGY

Regional Setting

Bedrock

The uppermost bedrock unit in the study area consists of silty and shaly dolomites of the Silurian System (Willman et al. 1967). Bedrock units dip to the east approximately 4.0 m/km (Willman 1971). The bedrock surface slopes to the east-southeast toward a bedrock valley that slopes eastward toward Lake Michigan (Herzog et al. 1994).

Sediments

Bedrock in the study area is overlain by unlithified Quaternary sediments approximately 45 to 60 m thick (Piskin and Bergstrom 1975, and ISGS well records on file). On the east side

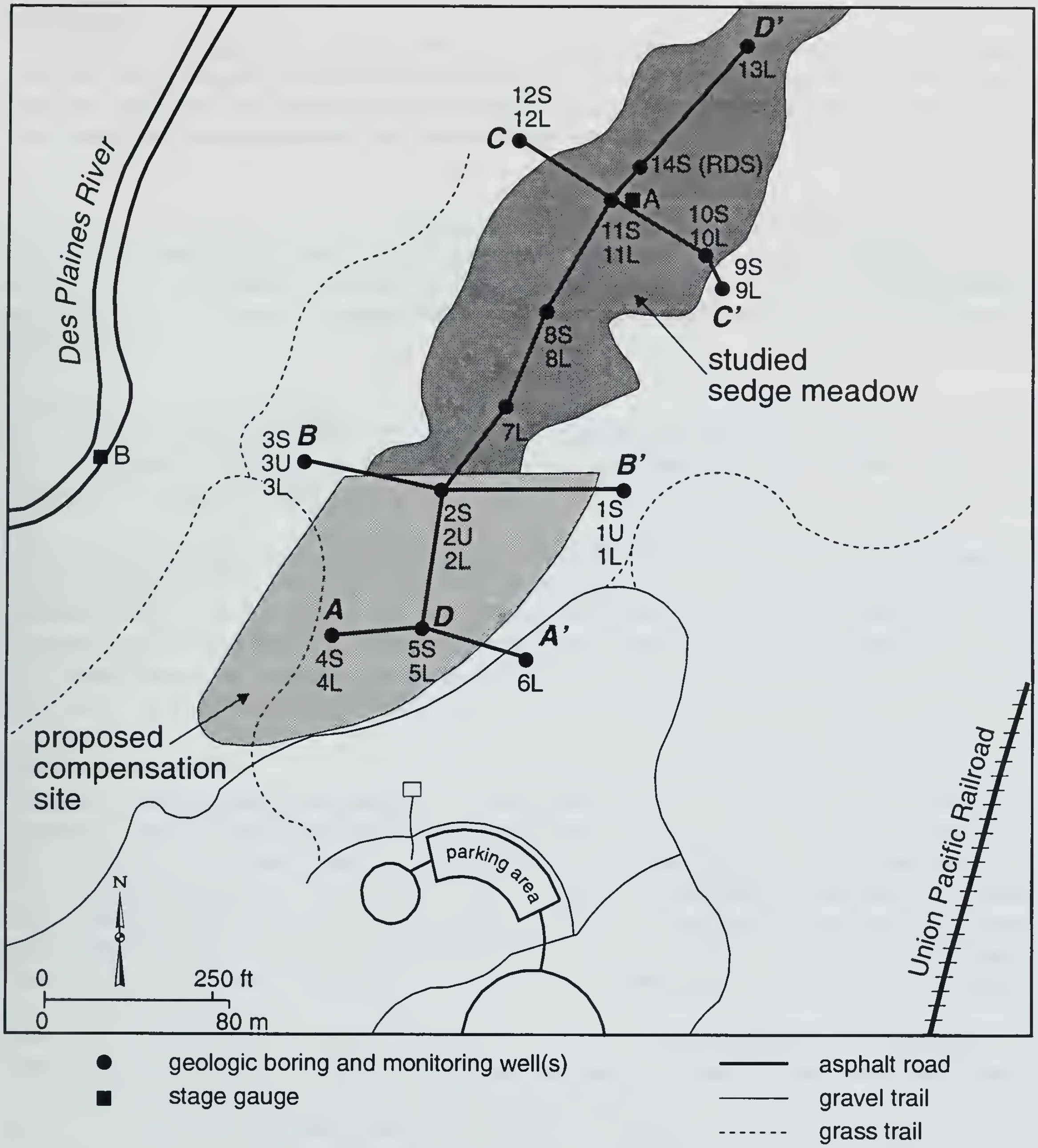

Figure 3 Site map showing the locations of monitoring wells, lines of cross section, and stage gauges.

of the study area, sediments are mapped (Berg and Kempton 1988) as silty and clayey diamictons of the Wedron Formation of the Wisconsinan Stage. Diamicton is a term used to describe all very poorly sorted sediments, such as glacial tills and debris flows, without implying an origin of the deposit. On the west side of the study area, multiple sedimentary units have been mapped. From the surface downward, they consist of: less than 6 m of clay, silt, and sand of the Cahokia Alluvium, greater than 6 m of silt and clay of the Carmi Member of the Equality Formation, and less than 6 m each of sand and gravel of the Henry Formation and silty and clayey diamictons of the Wedron Formation (Berg and Kempton 1988). Other sediments may be present below these units as well.

Topography
Total relief of the site (fig. 1) is approximately 3 m (U.S. Geological Survey 1993). The general land surface of the site slopes from the uplands on the east toward the Des Plaines River on the west. However, the compensation site and the sedge meadow are located in a small trough that trends northeast-southwest and slopes to the northeast.

Soils
Soils in the compensation area are mapped as Nappannee silt loam, Morley silt loam, Zurich silt loam, and Hennepin loam (U.S. Department of Agriculture 1970); these soils are not listed as hydric by the Natural Resources Conservation Service (NRCS) (U.S. Department of Agriculture 1991). Soils in the sedge meadow are mapped as Sawmill silty clay loam, which is listed as hydric.

Regional Geologic History
The sediments at this site reflect the effects of several late Wisconsinan glaciers that advanced across the site. In places, each glacier partially eroded the deposits of earlier glaciers and deposited glacial till and outwash on top of the remaining sediment.

Sediments on the east side of the study area are glacial tills of the Wedron Formation that were deposited as moraines of the Lake Border Morainic System that trend north to south (Willman 1971). To the west of the site, glacial meltwaters carried in the Des Plaines River valley deposited sand and gravel outwash. In addition, lakes formed in proglacial positions and in outwash valleys dammed by glacial ice or sediments, leading to the deposition of lacustrine sediments found in the area (Willman 1971).

Site Characterization

Cross sections showing site geology are presented in Appendix A. The lowermost unit of sediments encountered during drilling comprises silty clay, clayey silt, and sandy silt (unit A). Up to 7 m of this unit was penetrated during drilling. This unit, which underlies the entire site, has a variable character. In boring 3, the unit contains two sequences of bedded, varve-like sandy silts separated by a structureless clayey silt. This sequence may indicate glaciers approaching the site and depositing coarser sediment in a proglacial lake. This sediment is likely classified as part of the Equality Formation, Carmi Member (Late Wisconsinan Substage).

Unit B is a diamicton that in general has the characteristics of Wadsworth till (Willman and Frye 1970). Unit B occurs at land surface in the eastern part of the site adjacent to well 1, but intertongues with and is buried by sediments of unit A in the central part of the site; it was not encountered in the western part of the site. Unit B is stratified in places, indicating that some of the sediment may have been transported as mudflows after deposition. The glacier that may have deposited this diamicton was likely the source of the sand and varve-like sediments in unit A. Unit B is up to 6.5 m thick. This sediment is likely classified as part of the Wadsworth Till Member of the Wedron Formation (Late Wisconsinan Substage).

Unit C is a sand and gravel body that overlies unit A and unit B in the western and central parts of the site, but is absent in the eastern part of the site. Unit C is up to 4.5 m thick, and is thickest in the central portion of the site. The stratigraphic relationships shown on the cross sections suggest that unit C was deposited in a former river channel that eroded downward into the sediments of units A and B. This channel may have at one time been part of a river system that carried meltwaters in the Des Plaines River valley and then was abandoned during later river downcutting. This unit is likely classified as part of the Mackinaw Member of the Henry Formation (Late Wisconsinan Substage).

Unit D, a sandy to clayey silt that overlies unit C, is absent in the eastern part of the site. The unit is up to 1.3 m thick. The color of this unit changes according to landscape position, from brown in upland areas to olive and black in sedge meadow areas. The genesis of the deposit is not known, but it may have formed through deposition in an occasionally flooded backwater after the channel was abandoned. The uncertain genesis of this sediment does not permit assignment to a specific geologic unit.

Overlying a portion of unit D is unit E, a peat to muck deposit at land surface in the north-central part of the site located in the trough in which the sedge meadow is located. This unit also includes an organic mat comprising lake sedge *(Carex lacustris)* and other wetland plants at land surface in the central parts of the sedge meadow that are more regularly inundated; this mat contains little clastic material. This unit is up to 0.5 m thick, and is likely classified as part of the Grayslake Peat, a Late Wisconsinan Substage to Holocene Stage deposit.

HYDROLOGY

Regional Setting

Water-well records for this area indicate that water for some private homes is withdrawn from various sand and gravel beds interlayered in glacial tills and other glacial sediments at depths of 12 to 43 m. Other wells in the region withdraw water from carbonate bedrock at depths of 45 to 60 m.

Regional slope and surface-water flow is from the uplands east of the site toward the Des Plaines River to the west. The Des Plaines River flows toward the south. Total topographic relief between the crest of the slope 1.5 km to the east and the Des Plaines River directly adjacent to the site on the west is about 25 m. Local surface-water flow is toward the compensation site and the sedge meadow from the east, south, and west and then northward toward the Des Plaines River. A small, ephemeral stream channel drains into the wetland from the southeast, and may supply sufficient clastic material to affect the plant assemblage at the discharge point (S. Simon, Illinois Natural History Survey, pers. comm.). In general, local and regional ground-water flow patterns may be similar in plan to surface-water flow patterns.

Climate

Total average annual precipitation in the region is 83 cm, and is highest in the spring and summer months (U.S. Department of Agriculture 1970). Most ground-water recharge is estimated to occur during spring, fall and winter when precipitation is moderate or high and when evapotranspiration is low (Hensel 1992).

The growing season in Lake County is about 170 days (U.S. Department of Agriculture 1970) using the period free of a killing frost, or -2.2°C air temperatures (U.S. Department of Agriculture 1994, undated). Other methods of calculating the growing season have been used that may give a longer estimate, such as the period that soil temperatures are above biologic zero (4°C) (U.S. Army Corps of Engineers 1987), but soil-temperature data for Illinois are scarce. Soil-temperature data from the Morton Arboretum (80 km south of the site) indicated a longer growing season (P. Kelsey, pers. comm), estimated at about 213 days when corrected for the more northerly position of the study area. Observations at this site in spring of 1995 and 1996 indicated that wetland vegetation growth matched the longer growing season. Therefore, the longer growing season calculated from soil-temperature data is likely more accurate, and therefore will be used in this report. In this specific situation, the use of the longer growing season does not alter the conclusions of this report.

During the monitoring period, precipitation was quite variable. Figure 4 shows rainfall recorded about 13 km west of the site at the Lake Villa reporting station. These data were obtained from

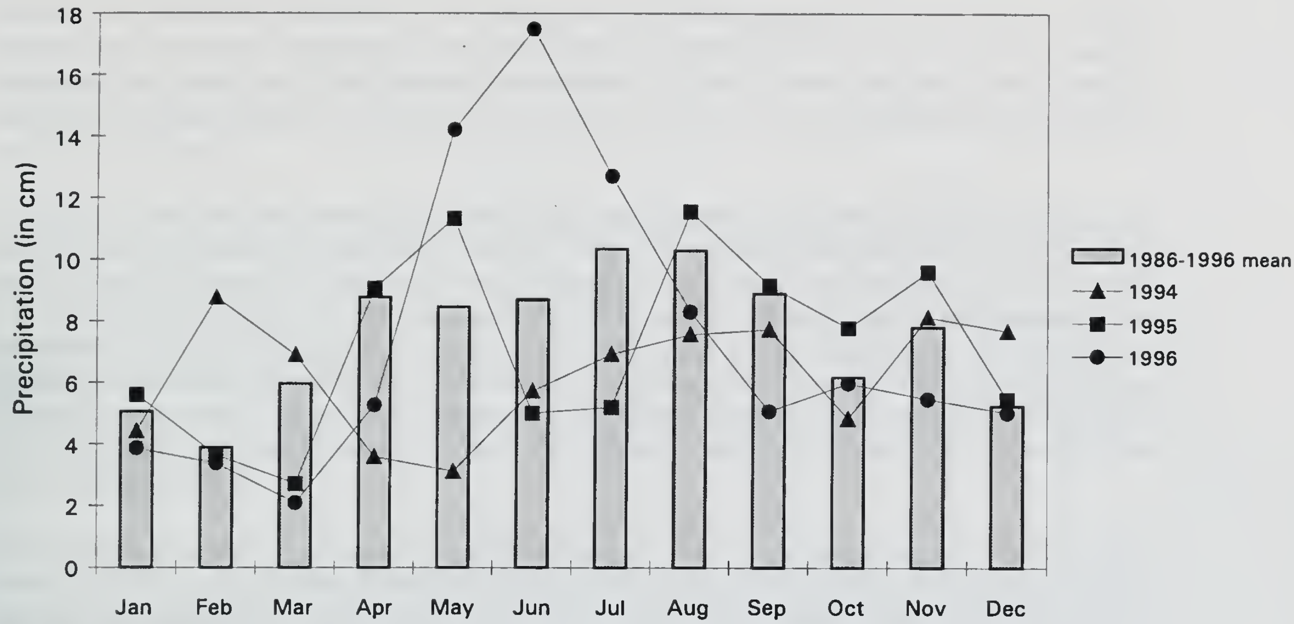

Figure 4 Precipitation data for the region, including summarized mean monthly precipitation between 1986 and 1996 and running 2-month averaged precipitation during January 1994 through December 1996 recorded at Lake Villa, Illinois (Illinois State Water Survey Midwestern Climate Information Center).

the Illinois State Water Survey's Midwestern Climate Information Center in March 1997 (Midwestern Climate Information Center 1997). Average monthly precipitation is shown from the 1986 to 1996 period. Precipitation data recorded during the monitoring period are presented as a running two-month average [e.g. June = (May+June)/2]; this type of averaging smooths the data and more clearly shows the long-term trends. Precipitation ranged from much below average to much above average. The general trends were as follows. During 1994, the late winter to early spring and late fall to early winter were wetter than average, with a drier than average late spring, summer, and early fall. In 1995, the late spring and late summer through early winter were wetter than average and the late winter, early spring and early summer were drier than average. In 1996, late spring and early summer were wetter than average, with a drier than average late winter, early spring, and late summer through fall.

Site Characterization

Ground Water

The purpose of the hydrogeologic investigation was to identify the water sources that supply the sedge meadow to determine if they could be used in the proposed compensation area, and to identify hydrologic differences between the compensation area and the sedge meadow in order to propose potential compensation measures.

Monitoring wells were installed in various geologic units throughout the site to: 1) identify water levels within each unit, 2) infer potential ground-water flow directions, 3) estimate source areas for ground-water input, and 4) determine the areal extent of wetland hydrology. Water levels measured during the monitoring period are shown in Appendix B. The screened intervals of each monitoring well in relation to the geologic units on site are shown on cross sections in Appendix A.

<u>Ground-water conditions in the soil zone</u>

As stated in the 1987 Wetlands Delineation Manual (U.S. Army Corps of Engineers 1987), the occurrence of wetland hydrology depends on the period of time sediments are saturated to

within 0.3 m of the land surface. If that saturation level is exceeded for 12.5% of the growing season then wetland hydrology is proven to exist, if between 5% and 12.5% then wetland hydrology may exist, and if less than 5% then wetland hydrology does not exist. Given that this site has a growing season estimated to be 213 days, 12.5% of the growing season is 27 days and 5% is 11 days.

In order to determine the extent of wetland hydrology on site, monitoring wells 1S through 5S and 8S through 12S were installed in the soil zone. These wells normally were 0.75 m deep, had screened intervals of 0.45 to 0.75 m in depth, were packed with sand to 0.3 m in depth, then were sealed to land surface with bentonite. The geology of each boring was generally not considered when constructing these shallow wells because soil-forming processes likely cause significant secondary porosity and permeability that affect water levels as much or more than primary geologic characteristics (Miner and Simon 1996). Wells were partially or fully screened in units C through E, which occur at or near land surface. Well construction measurements are shown in Appendix C.

Water levels recorded in all soil-zone wells located in the compensation area and the sedge meadow are shown in figures 5 and 6, respectively. During spring 1995, water levels indicate that wetland hydrology is present in the vicinity of wells 2S, 5S, and 8S through 12S. It should be noted that excavation occurred in September 1995, so 1996 measurements cannot be used to describe the undisturbed conditions at the site.

The area of wetland hydrology indicated by the 1995 data generally matches the area where wetland vegetation is dominant. However, wetter than average periods during the spring in 1995 may have caused wetland hydrology to occur in wells 2S and 5S, which are located in an area that lacks a dominance of hydrophytic vegetation (Keene and Nugteren 1993) and therefore probably would not exhibit wetland hydrology regularly.

Figure 7 shows water levels in the soil zone on May 2, 1995, during a period of above average precipitation. The contours of the water table suggest that water flows into the compensation site and sedge meadow from the east, south, and southwest, then northward. Figure 8 shows water levels measured in S wells on April 2, 1995, and shows that during periods with less precipitation, the northeastward component of flow does not occur and flow into and through the wetland is in general to the northwest. The difference in flow behavior indicates that the upland between the study area and the Des Plaines River to the west is only a source of recharge for the wetland during periods of heavy precipitation and infiltration.

<u>Ground-water conditions in unit C</u>

Unit C underlies the majority of the compensation site and the entire sedge meadow at a depth of approximately 0.3 to 1.5 m. Water levels and flow directions in unit C determine the role that it plays in the maintenance of the sedge meadow and its potential for use as a water source for the compensation area. A number of wells are installed in unit C throughout the site as shown in the cross sections in Appendix A. Wells 2U and 2L are nested to determine vertical flow directions in unit C. Water-level elevations in wells screened in unit C in the compensation area and the sedge meadow are indicated in figures 9 and 10 respectively.

Figure 11 shows contours of hydraulic head in unit C on May 2, 1995, during a period of high precipitation. Ground water flows into the compensation area from the southwest, south, and southeast, then northward toward the sedge meadow.

Figure 12 shows contours of hydraulic head in unit C on April 2, 1995, during a period of less precipitation. The flow pattern is similar to that described above, but shows no eastward component of flow. This may indicate that during periods of heavy precipitation resulting in ground-water recharge, the upland west of the study area and east of the Des Plaines River be-

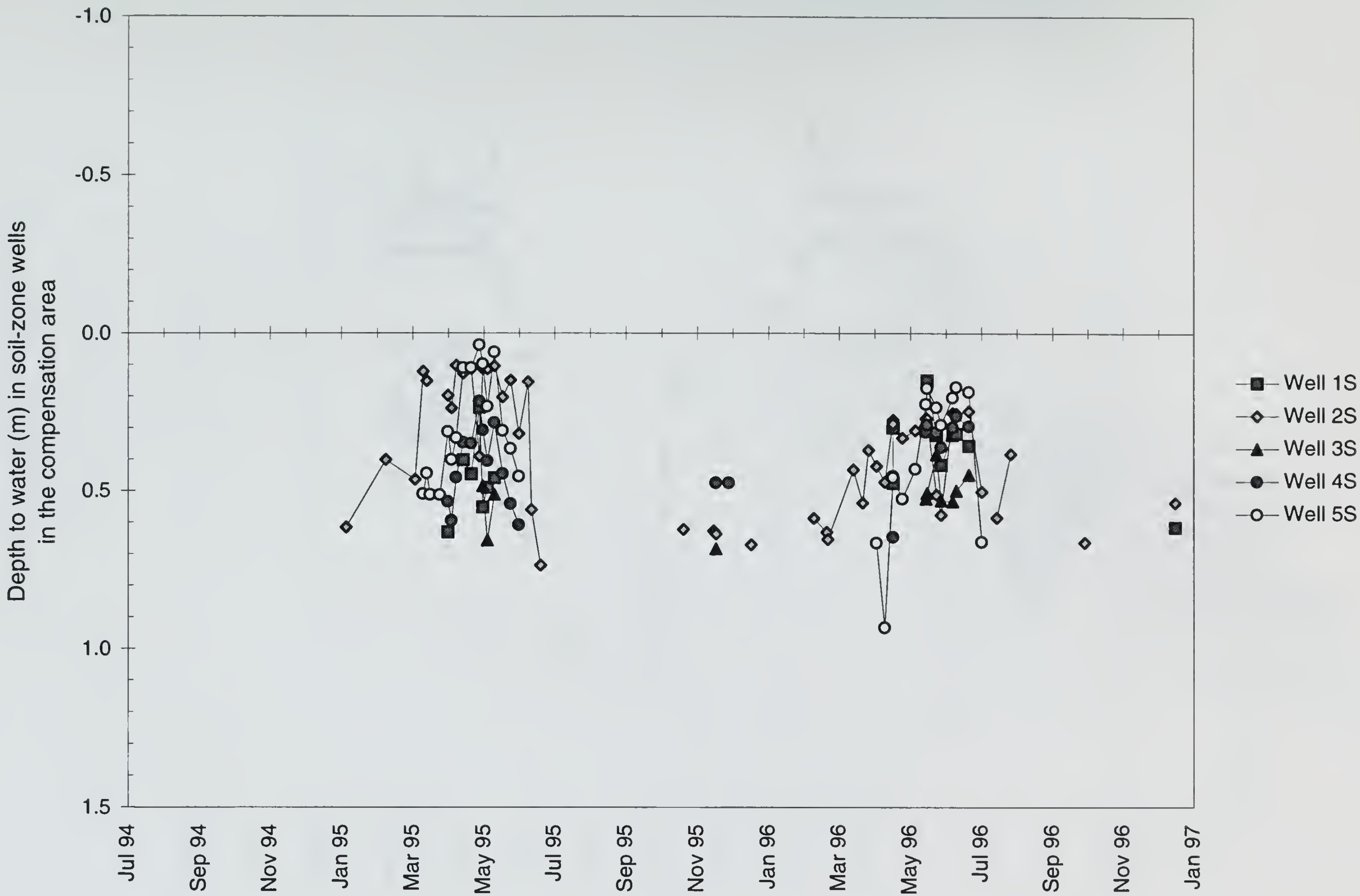

Figure 5 Depth to water below land surface in soil-zone (S) monitoring wells in the proposed compensation site recorded between January 1995 and December 1996. Negative values indicate water levels above land surface.

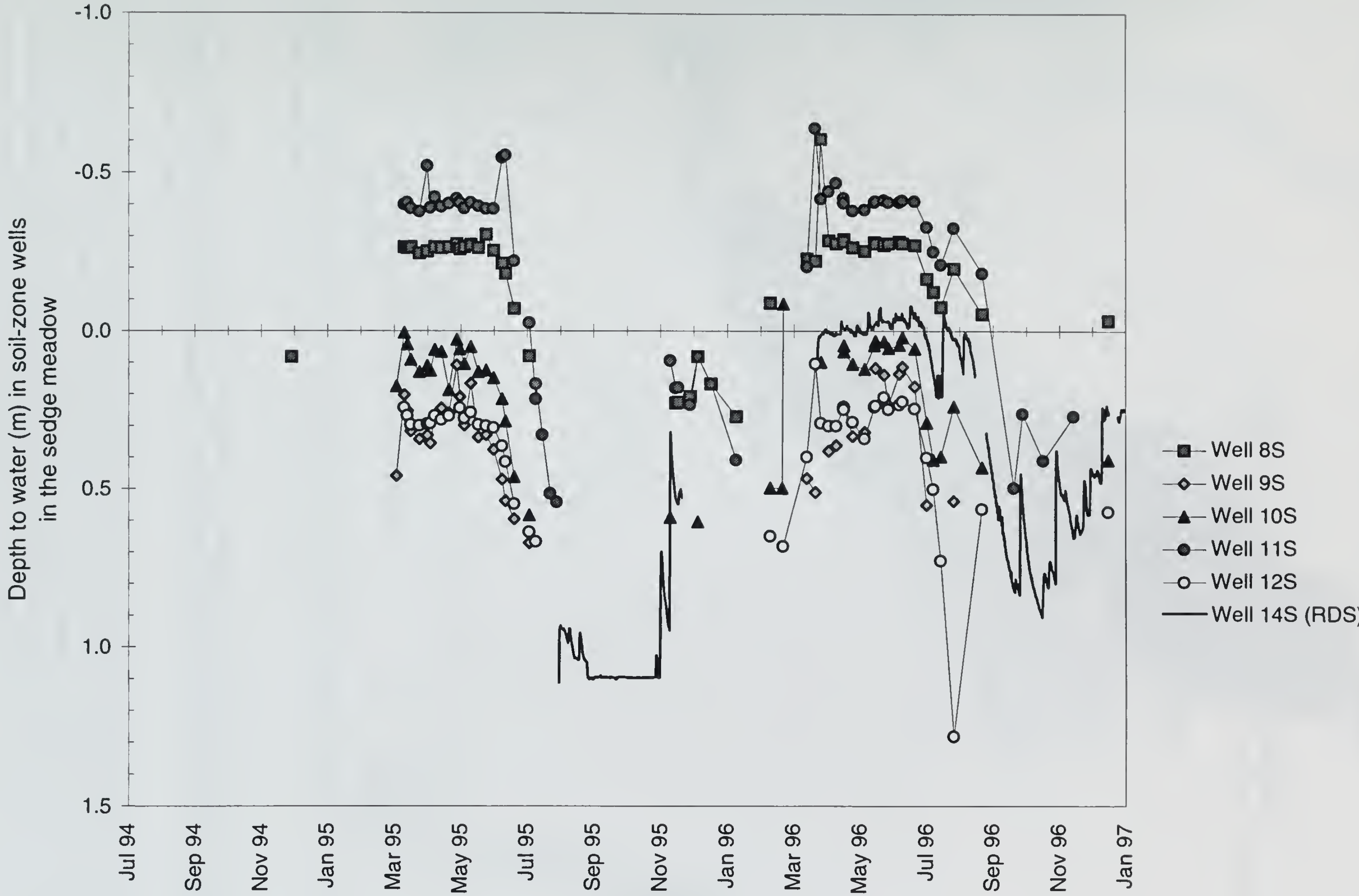

Figure 6 Depth to water below land surface in soil-zone (S) monitoring wells in the sedge meadow recorded between November 1994 and December 1996. Negative values indicate water levels above land surface.

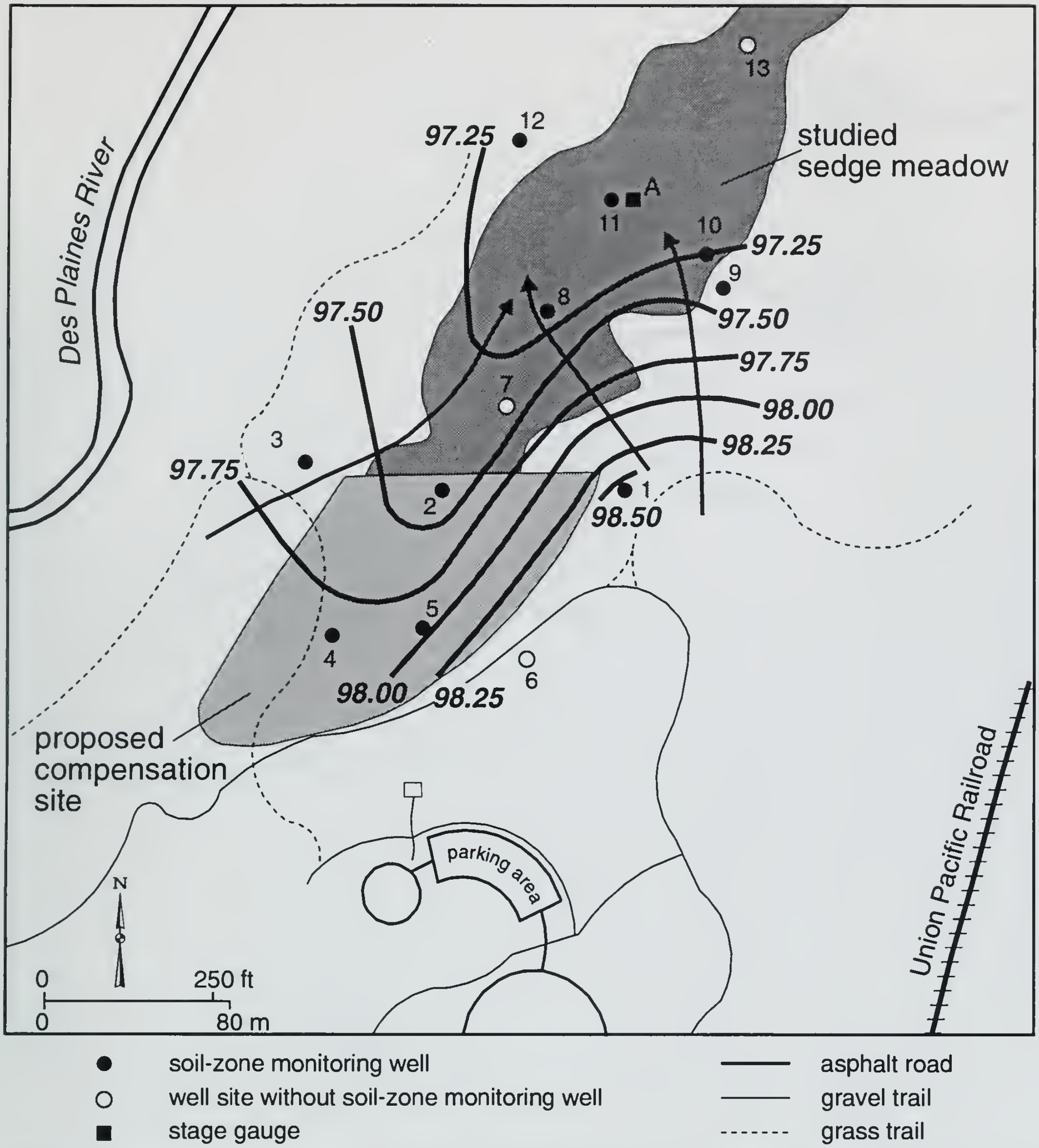

Figure 7 Contours of the water table measured on May 2, 1995, in soil-zone (S) wells, and estimated ground-water flow directions (arrows). Contour interval is 0.25 m.

comes saturated and causes flow northeastward, helping to recharge unit C and to cause ponding of water in the sedge meadow. As recharge lessens, ground-water flow westward through unit C returns.

The inferred direction of vertical flow in unit C is shown by comparing water levels in wells 2U and 2L (figure 9). Downward flow through unit C in the majority of measurements is indicated by water levels in well 2U that are greater than or equal to levels in well 2L; these differences were sometimes as large as 0.22 m, indicating potentially significant downward flow. Periods of inferred upward flow were also present as noted by measurements of levels in 2L that were higher than those in 2U, but the differences in elevation were normally very small (0.01 to 0.05 m), indicating less significant flow. Upward flow is possibly caused by discharge

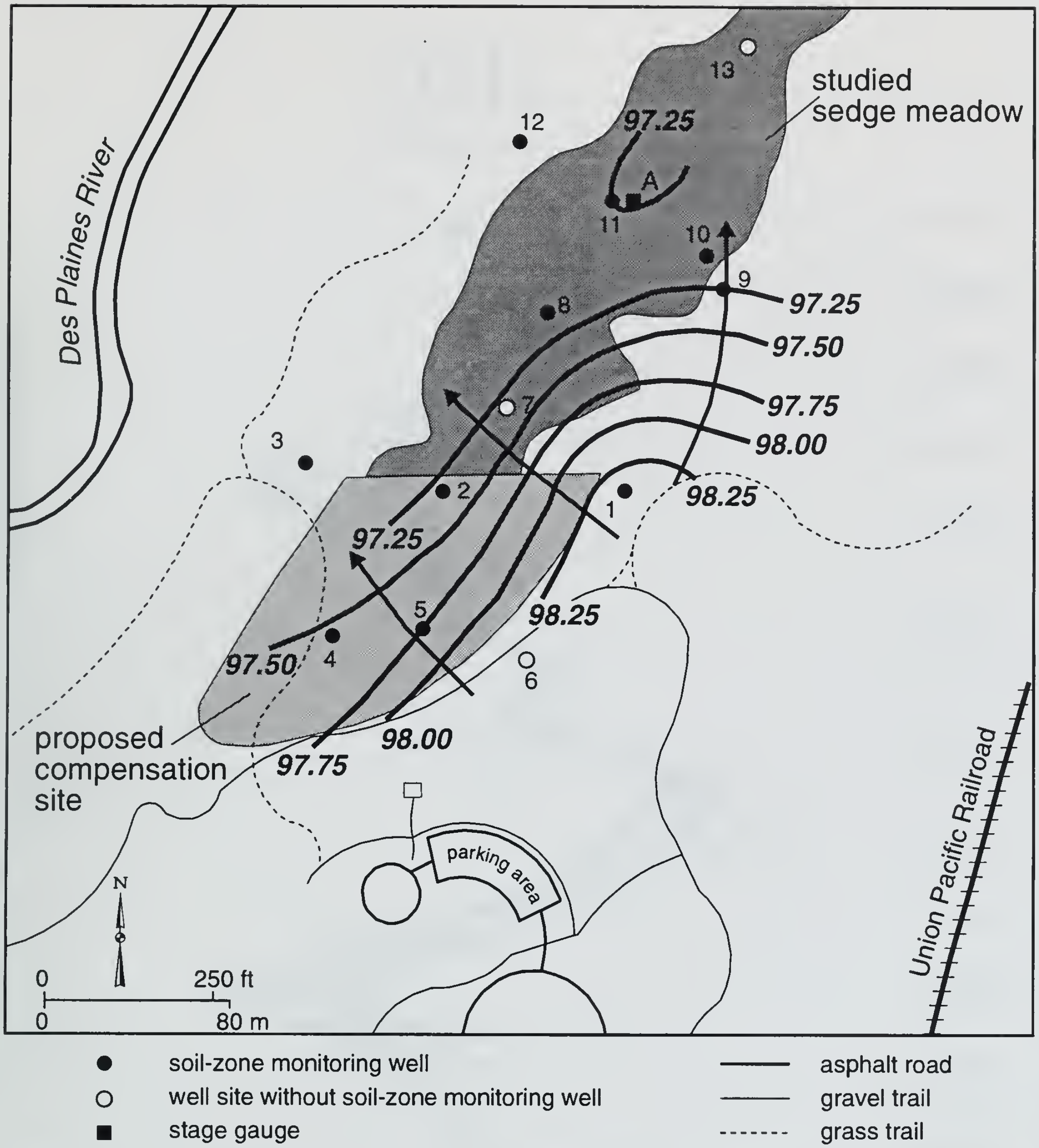

Figure 8 Contours of the water table measured on April 2, 1995, in soil-zone (S) wells, and estimated ground-water flow directions (arrows). Contour interval is 0.25 m.

from unit B at depth through fractures in the diamicton. No clear relationship of precipitation to direction of vertical flow through unit C was observed.

Hydrologic conditions in unit C vary from unconfined to confined. Water levels in well 2U are higher than the elevation of the upper surface of unit C from late fall or winter through midsummer, indicating confined conditions. In midsummer, water levels drop below the elevation of the top of the unit and indicate unconfined conditions. These trends are only slightly related to precipitation conditions. For example, an early change from unconfined to confined conditions in fall 1995 was accompanied by several months of heavy rainfall, and record rainfall in summer 1996 may have extended the period of confined conditions into August. However, no apparent relationship exists between saturation levels and any particular rainfall event or

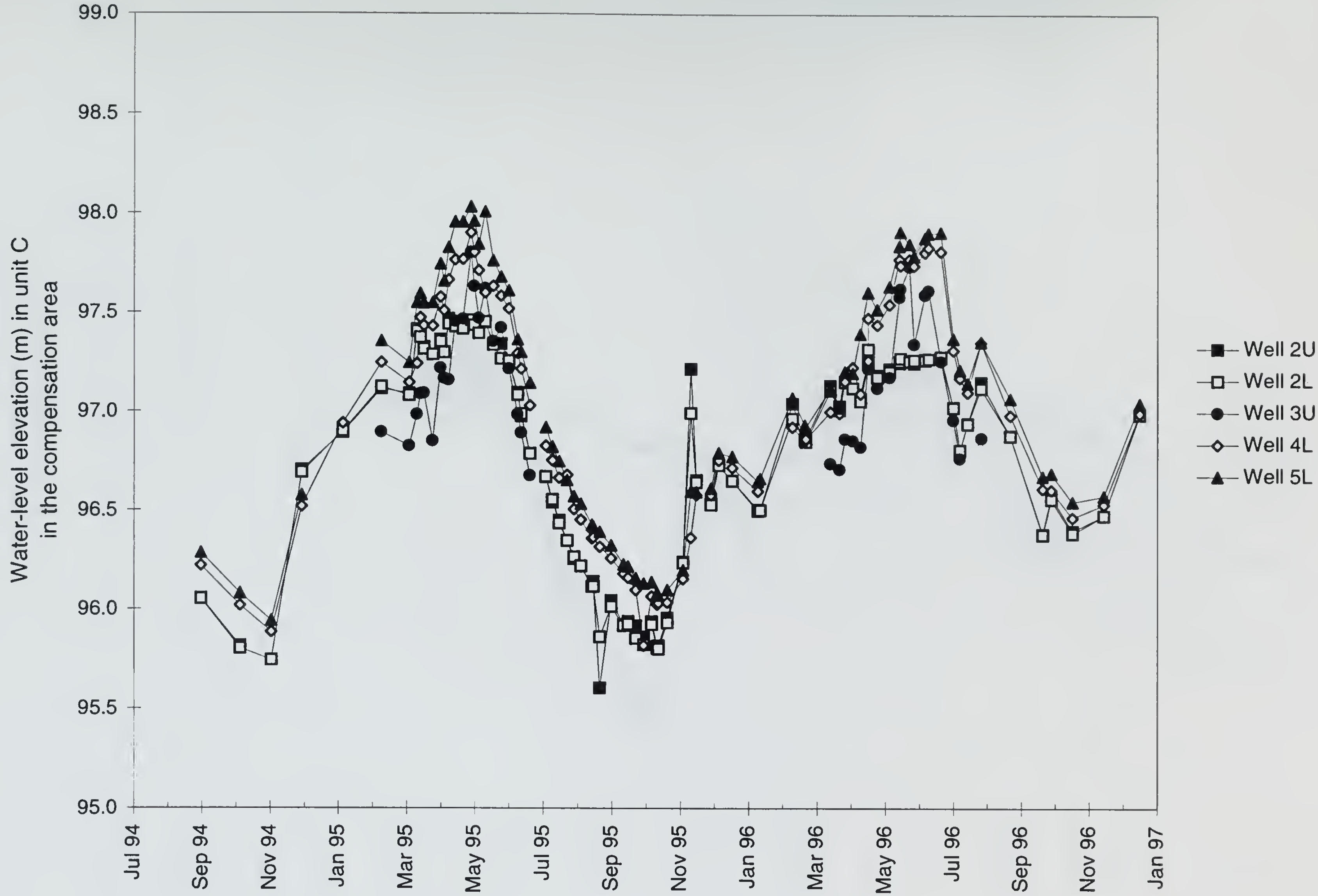

Figure 9 Water levels in wells screened in unit C in the proposed compensation area recorded between August 1994 and December 1996.

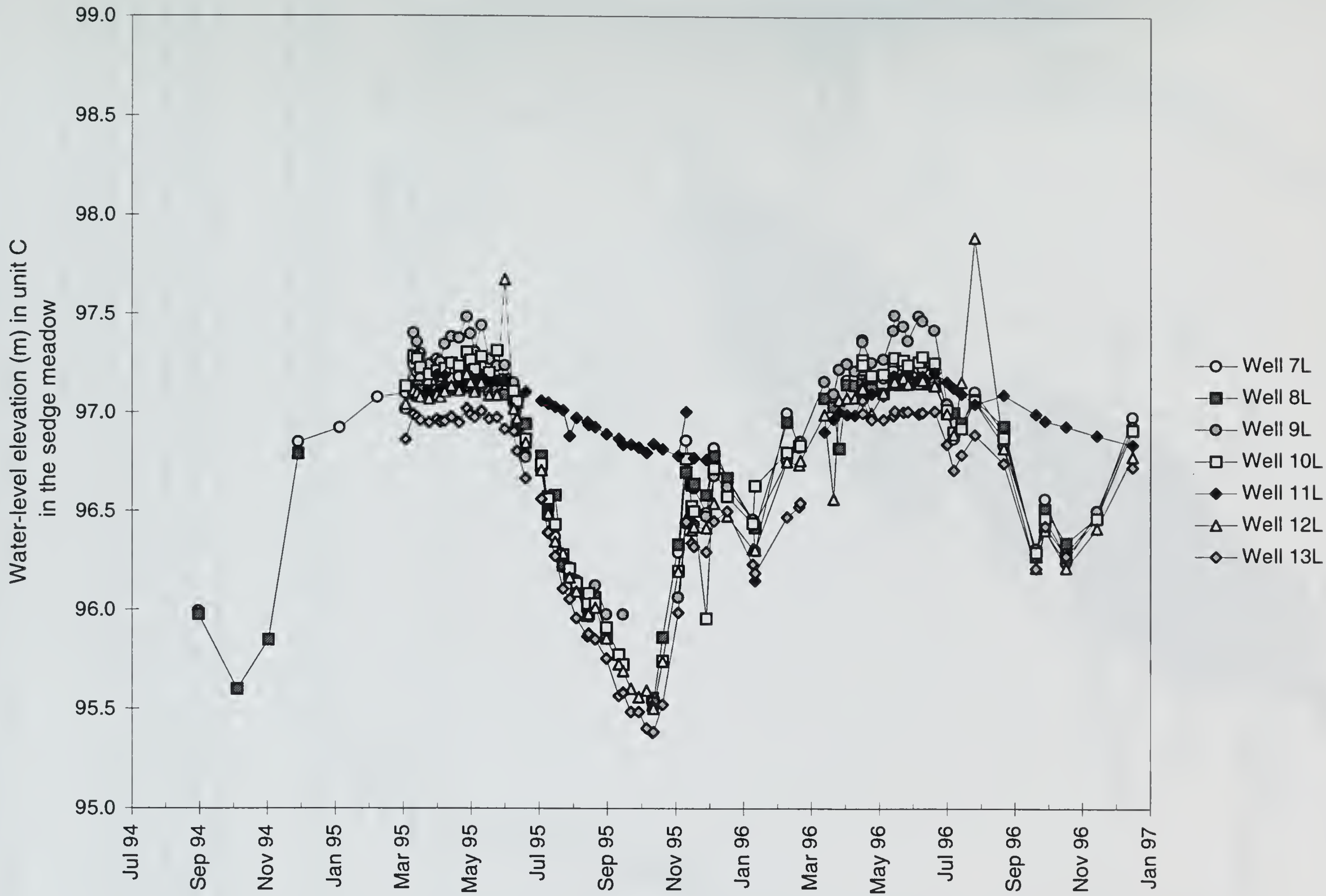

Figure 10 Water levels in wells screened in unit C in the sedge meadow recorded between August 1994 and December 1996.

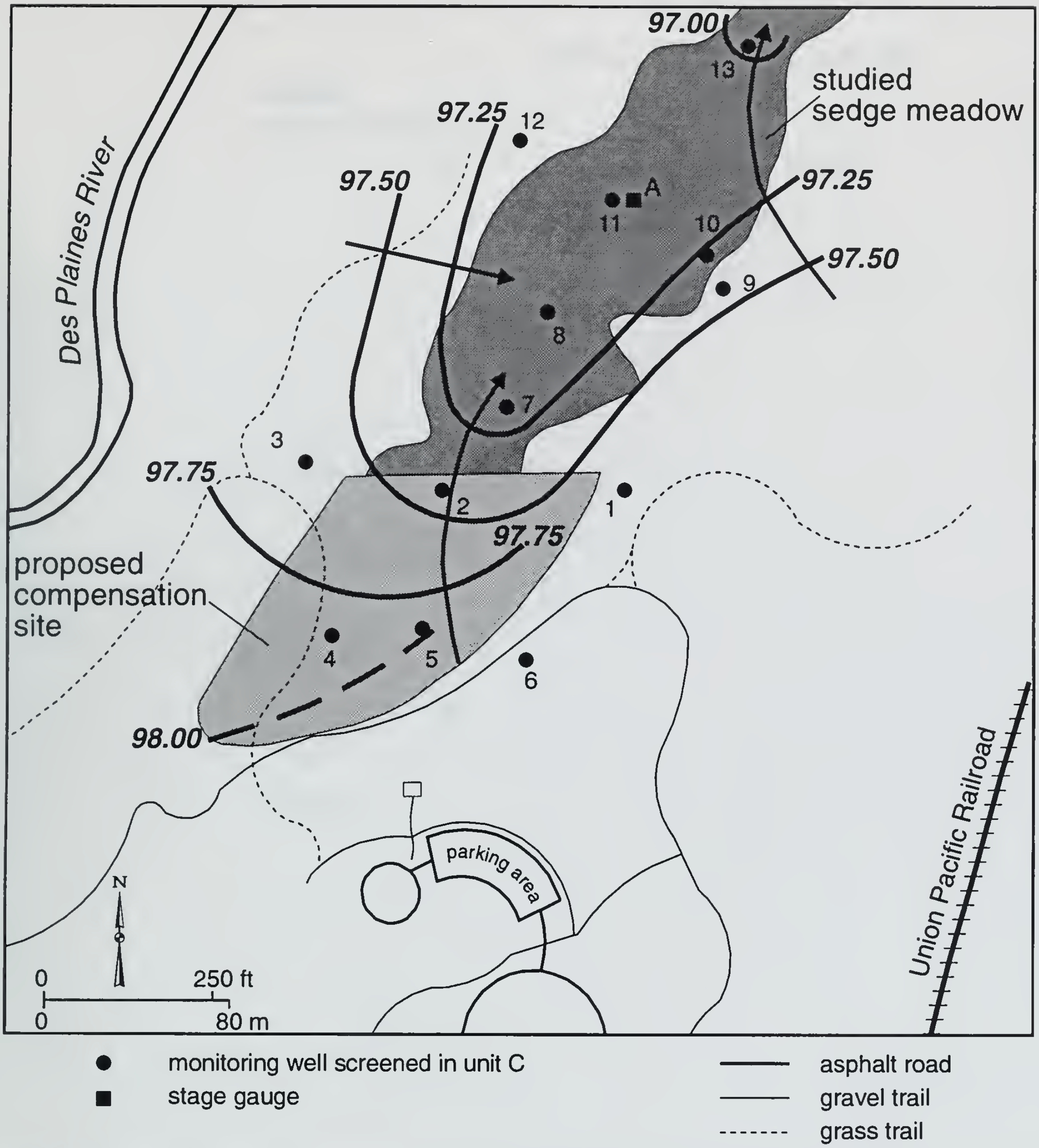

Figure 11 Contours of the potentiometric surface measured on May 2, 1995, in wells screened in unit C, and estimated ground-water flow directions (arrows). Contour interval is 0.25 m.

rainy month. For example, water levels in 2U in the drier months of March 1995 and April 1996 were generally equal to those recorded in the wetter months of May 1995 and 1996. This lack of relationship to individual rainy months or periods suggests that the pattern of saturation in unit C may be related to seasonal patterns of input versus output: ground water may be the dominant input versus evapotranspiration as the dominant output. Varying amounts of precipitation may have a secondary effect on water levels, but appear to act only to hasten or delay seasonal changes already occurring.

Given that unit C is present at very shallow depths, it is reasonable to assume that soil-forming processes have created conduits for ground-water flow through units D and E above, so that unit C may behave in a semi-confined or unconfined manner even when water-level measure-

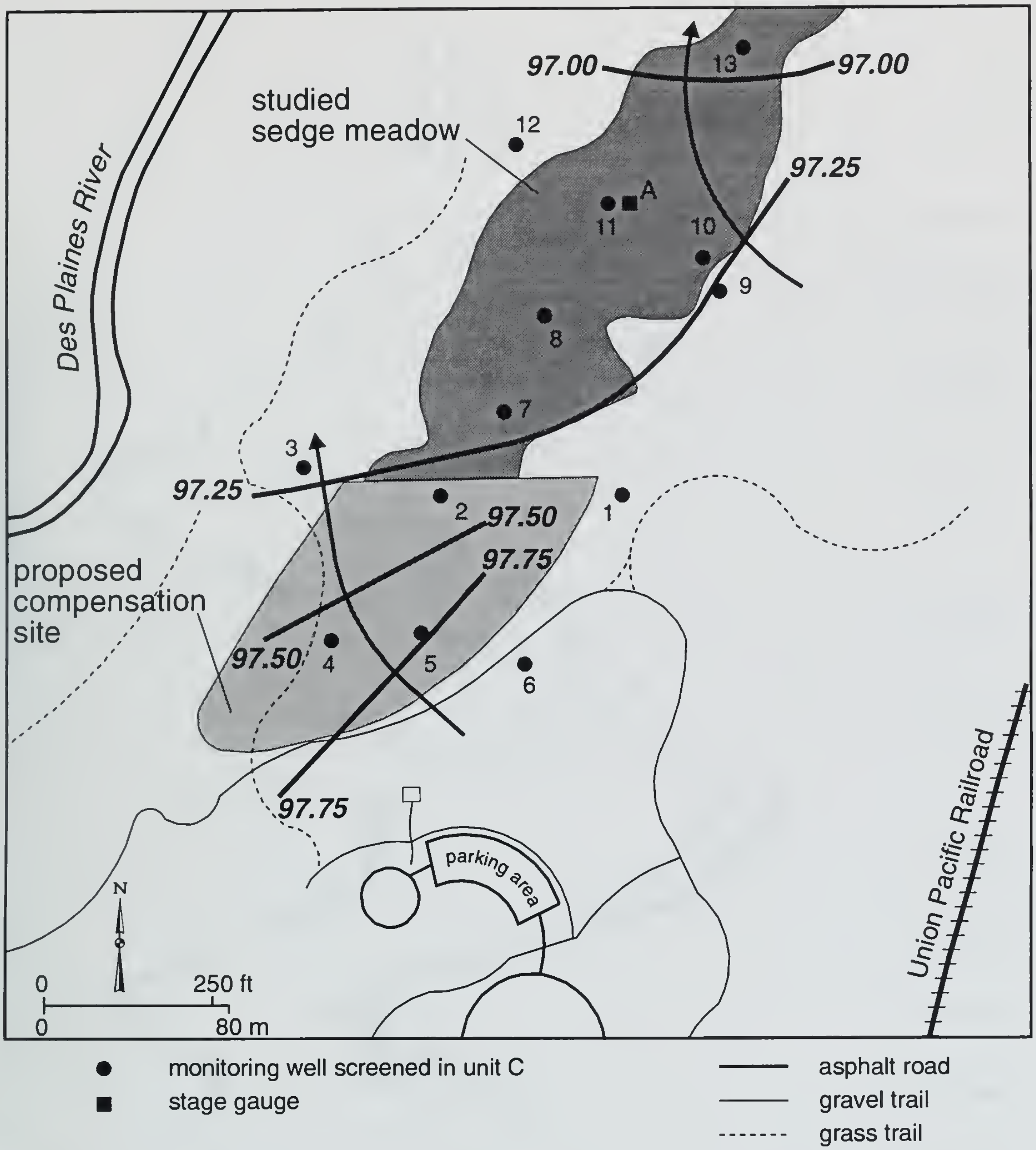

Figure 12 Contours of the potentiometric surface measured on April 2, 1995, in wells screened in unit C, and estimated ground-water flow directions (arrows). Contour interval is 0.25 m.

ments indicate that a confined condition exists. Water levels in units C, D, and E may be hydrologically connected and behave in concert, although changes in saturation of the fine-grained matrix of units D and E may lag behind water-level changes measured in wells. Surface water appears in the sedge meadow when water levels measured in unit C are higher than land surface, as discussed later.

Ground-water conditions in other units

Figure 13 shows the water levels measured in selected wells 1 through 3 (U and/or L) to compare levels in unit C to those in units A and B. Well 1U is screened in unit B, well 2U is screened in unit C, and well 3L is screened in unit A. These levels are compared to determine if hydrologic conditions exist that would allow ground-water flow into unit C from adjacent units.

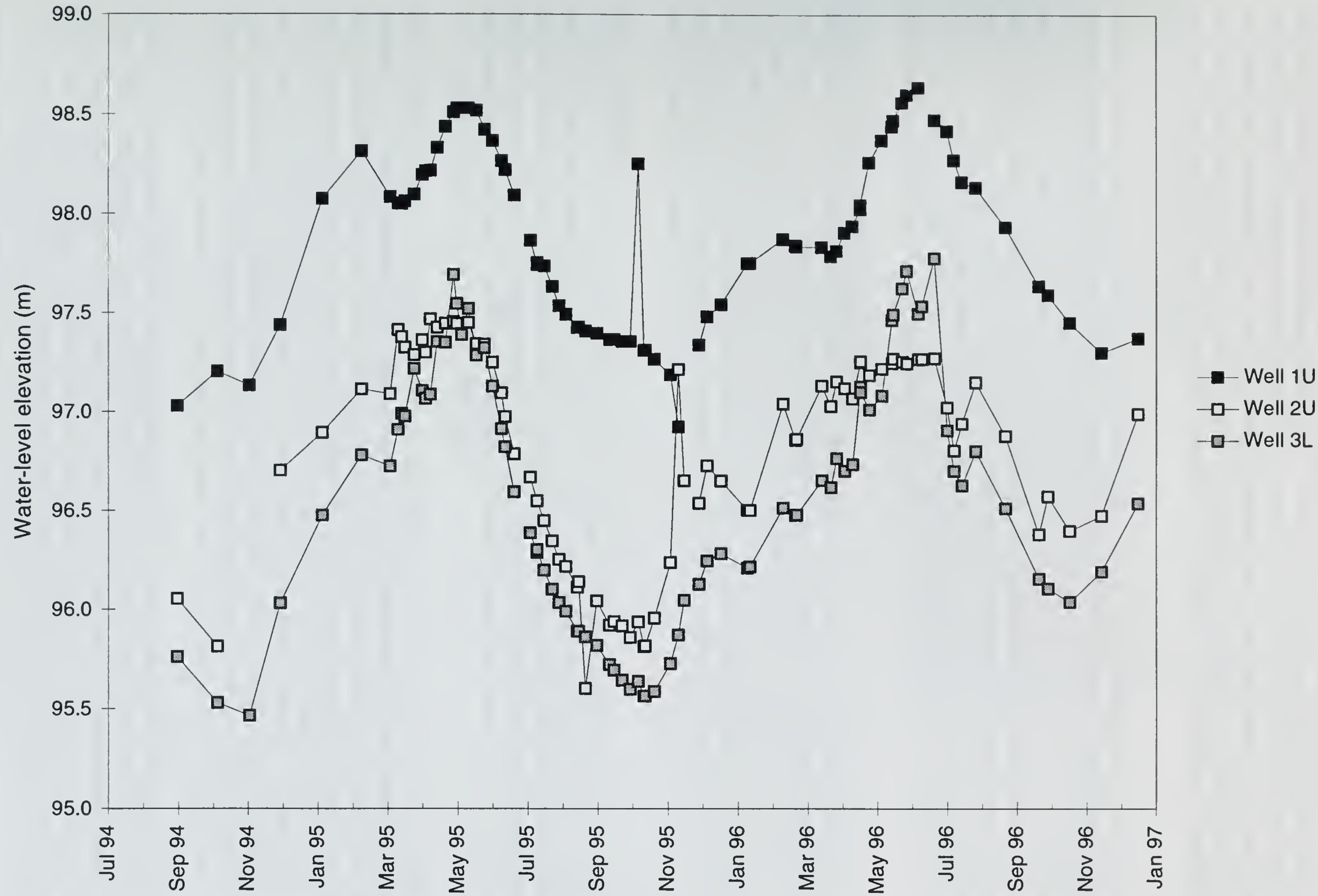

Figure 13 Water levels in wells located in unit A (well 3L), unit B (well 1U), and unit C (well 2U).

Water levels in unit B are consistently higher than those in unit C, indicating that the potential exists for ground water to discharge into unit C. However, unit B is a silty clay diamicton, so that the hydraulic conductivity of the matrix is relatively small and the amount of water the unit is capable of transmitting may also be small. Alternatively, fractures noted in the unit likely increase the secondary porosity. Also, unit B is located at land surface to the east, which may act as a large recharge area. Given these conflicting inferences, the total effect of discharge from B to C could not be quantified.

Water levels in unit A are usually lower than those in unit C, indicating that ground water discharges westward from unit C into unit A toward the Des Plaines River, except during periods of high precipitation and presumed recharge when this trend can reverse (e.g. May 1995, May and June 1996). This reversal does not happen during all periods of higher precipitation (e.g. August through December 1995), so that antecedent moisture conditions may be important. Because surface water appears in the sedge meadow prior to when the reversals were noted in May, it is not likely that this reversal of flow direction is required to cause the annual inundation of the sedge meadow. However, the duration of ponding may be affected by the additional input received by the sedge meadow during a flow reversal.

Potential for flow between nested wells

The potential for flow between all nested wells is shown in figure 14. Most flow potentials are less than ±0.1 m, and generally vary both upward and downward. No obvious relationship between precipitation and inferred direction of flow was found. All large or sustained flow potentials are downward (except one value at well 12S, which is likely a measurement error, and values at 11S, which are discounted due to a faulty well installation), indicating downward ground-water flow. Some of the more regular occurrences of downward flow potential include wells in boring 1, where 1S>1U>1L.

Surface Water

Surface waters in the study area include the Des Plaines River, ponded water in the sedge meadow, and two intermittent streams (not mapped) that flow into the sedge meadow. Stage gauges were installed in the sedge meadow adjacent to well 11 (A) and in the Des Plaines River west of the site (B) (fig. 3). Stage gauges were not installed in the intermittent streams because flow was never observed. Adding instruments to these streams that would record flash flows was considered beyond the scope of this study.

The catchment area for the sedge meadow is approximately 26 hectares of steeply sloping ground. Significant amounts of runoff are expected to be generated by this area, given that lesser permeable glacial till occurs at land surface. Dry, intermittent stream channels that lead into the sedge meadow carry flash flows as shown by debris lines. Vegetation that is more silt tolerant is present at the mouths of the channels (S. Simon, Illinois Natural History Survey, pers. comm.), but this vegetation does not extend far into the sedge meadow. Surface water ponds seasonally in the sedge meadow, where a slightly higher natural berm near well 14S helps retain water. In the sedge meadow north of the berm, land surface again slopes to the north into another seasonally ponded wetland area, then flows into the Des Plaines River.

Figure 15 shows water levels at stage gauges A and B and well 8L during the monitoring period. As stated earlier, surface water appears in late fall to late winter, then begins to decline in late spring until water disappears in midsummer. Levels in 8L indicate that surface-water levels in the sedge meadow (gauge A) closely match elevations of water level measured in well 8L. This indicates that surface water in the sedge meadow is hydrologically connected to ground water in units C through E as discussed earlier, so that when standing water exists in the sedge meadow then at least the macropores of units C through E are saturated.

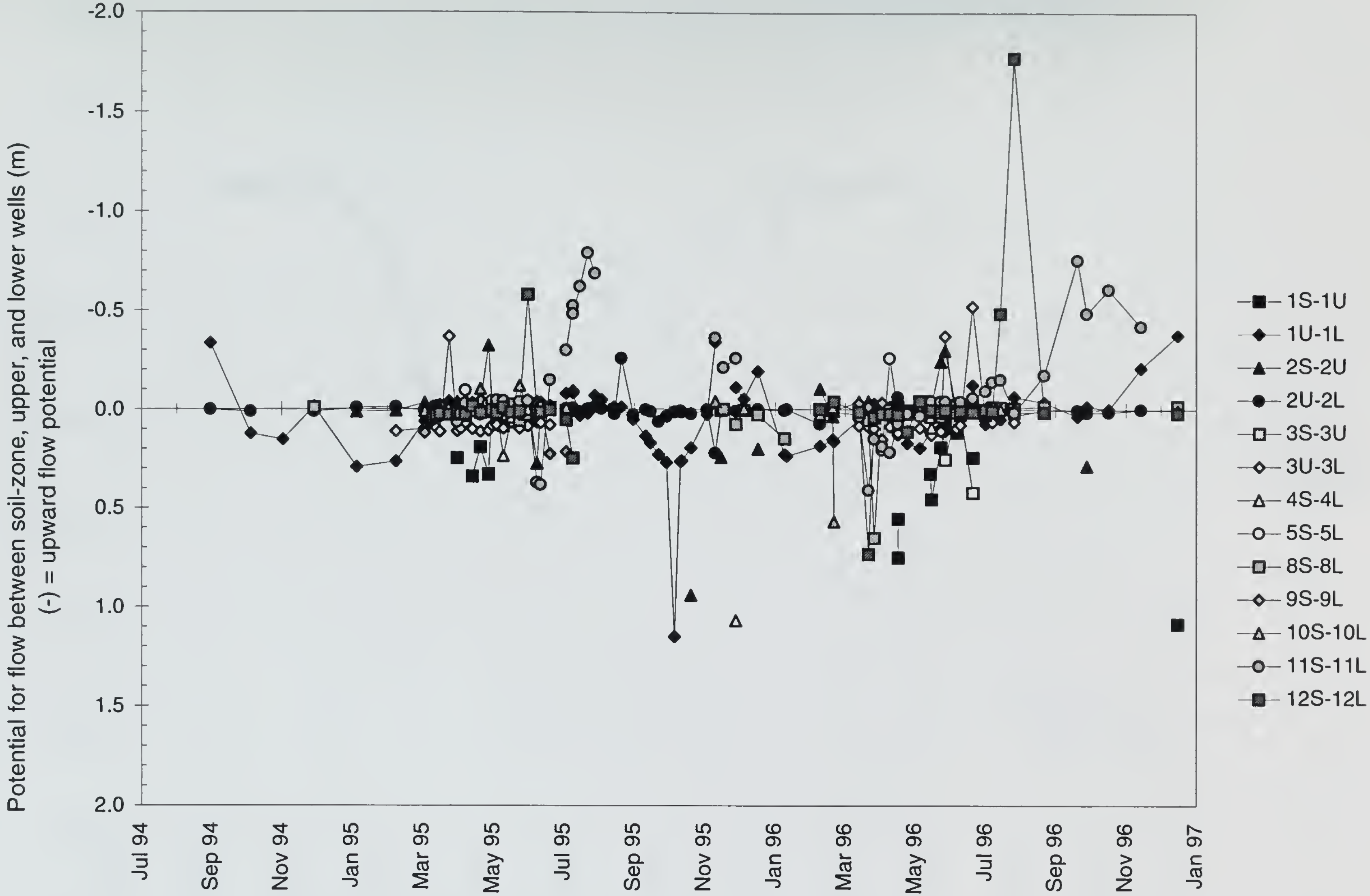

Figure 14 Potential for flow between selected, nested monitoring wells between August 1994 and December 1996. Negative values indicate an upward flow direction.

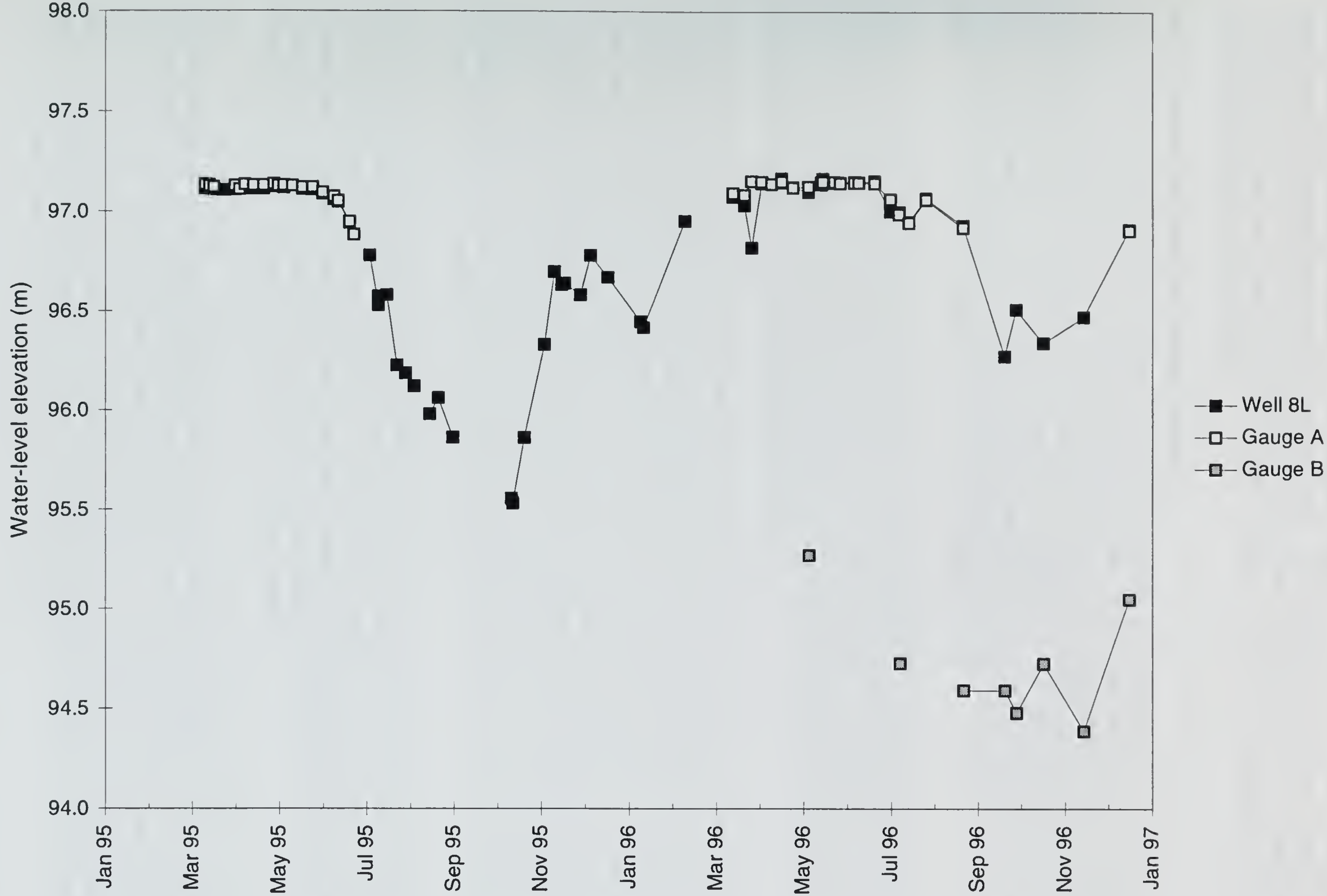

Figure 15 Water levels recorded from well 8L and stage gauges A and B between March 1995 and December 1996.

Water levels in the sedge meadow do not exceed about 97.2 m (fig. 15), the approximate elevation of land-surface near the berm by well 14S. This indicates that surface water flows over the berm and prevents higher flooding levels. Water levels in the Des Plaines River (gauge B) are much lower than those in the sedge meadow, which helps cause ground-water flow across the site from east to west.

Water Sources Supplying the Sedge Meadow

As noted above, surface water appears in the sedge meadow in the late fall to late winter, and dries up in midsummer. This hydrologic pattern allows for the development of the sedge meadow community that relies on dry conditions in the summer to propagate (S. Simon, Illinois Natural History Survey, pers. comm.). It is necessary to utilize the water sources that cause this pattern of inundation in order to produce favorable conditions for sedge meadow development in the compensation area. Aside from direct precipitation, the sedge meadow and the hydrologically connected unit C also receive ground-water discharge from adjacent sediments (units A and B), and surface-water runoff from surrounding uplands.

Although the relative importance of each water source to the sedge meadow remains unclear, they all contribute to supporting water levels in unit C. Since the compensation area is also underlain by unit C, and if water from unit C can be used to support the compensation area, then it is not necessary to determine which water source is of primary importance because all would be used. However, some discussion regarding the relative importance of each source is included for reference in the remainder of this section.

Surface-water runs off into the sedge meadow in intermittent stream channels. Some additional evidence of this is given by wells located in the low areas that show increases in water level corresponding with very large rain events that generate runoff and cause flooding. Figure 9 shows this response after large rainfall events in November 1995 and in March 1996, when water levels in wells 2U and 2L rapidly rise above levels noted in all other wells. However, water levels also decrease quickly from these two events, probably as the surface-water input is redistributed or discharged. Because this response is not seen at other times, it is likely that particular rainfall intensity and antecedent moisture conditions must exist prior to generating sufficient runoff to cause this effect. As noted earlier, because there is no obvious relationship between rainfall and the occurrence of surface water in the sedge meadow, runoff is not likely the dominant factor in determining the timing of ponding.

Ground water discharges into the sedge meadow from unit B to the east and unit A to the west. Although water levels in unit B are higher than those in unit C throughout the year, the relatively impermeable glacial till of the unit may not transmit large quantities of ground water. Unit A discharges ground water eastward toward the sedge meadow, but only during the spring when precipitation is high. As noted earlier, timing of ground-water discharge from unit A is not associated with the occurrence of ponding in the sedge meadow.

Water levels in unit C are confined from late fall to late winter through midsummer, when evapotranspiration draws down water levels to produce unconfined conditions. This and the apparent lack of a relationship to precipitation indicate that water levels in the unit are produced by a balance of seasonally variable inputs versus outputs. In the fall and winter, water levels slowly rise as steady ground-water discharge from unit B occurs. Precipitation-driven runoff may hasten recharge of unit C, but ground-water discharge saturates the unit by late winter even if less than average precipitation has occurred. As evapotranspiration increases in spring, water levels are drawn down until ponding disappears in midsummer.

COMPENSATION POTENTIAL OF THE STUDY AREA

Soils in the compensation area, which is southward of and uphill from the sedge meadow, are not mapped as hydric and therefore are not former wetland (Keene and Nugteren 1993). No evidence of field tiles was noted in a limited excavation in summer 1995. Therefore, the establishment of wetlands in the compensation area is not restoration, but creation. Normally creation is not a preferred compensation alternative, but the adjacent sedge meadow may act as a model to facilitate design.

To create wetland in upland positions, it is necessary to either increase the available water or to decrease the land-surface elevation so that the water table would be closer to the land surface for longer periods during the growing season. In the study area, it is not likely that water can be made to pond on land surface using dikes or other control structures without a liner, because water would flow downward to the water table in underlying unit C. Therefore, the only other option would involve excavation of the land surface.

The sedge meadow is located in an area underlain by sand and gravel of unit C. Standing water in the sedge meadow appears to be hydrologically connected to water levels in unit C, so that the standing-water elevation expresses the water level or hydraulic head in unit C. Water will inundate the area where the land surface intersects the water level in unit C. Given that the main hydrogeologic difference between the sedge meadow and the compensation site is elevation, if the land surface in the compensation site is lowered to intercept the water levels in unit C, then saturation sufficient to cause wetland hydrology may occur.

Because both surface and ground water help saturate unit C and support the sedge meadow, it is not necessary to determine which is most voluminous. However, it is necessary to determine if surplus water is available to account for the increased storage and presumed increased evapotranspiration that the new excavation would require. Because surface water in the sedge meadow stands at the elevation of the berm for several weeks during spring as surface water runs off northward into the Des Plaines River, excess water likely exists to compensate for increased storage and evapotranspiration in the excavated compensation area. If so, water levels in the sedge meadow would be unaffected by the compensation project. Also, as shown in figure 8, there was no ground-water flow northward from the compensation site into the sedge meadow prior to heavy spring rains in May 1995, yet the sedge meadow was already filled with surface water. Therefore, the sedge meadow probably does not rely on ground-water flow from the compensation site as its primary source area.

RECOMMENDATIONS

Although it is possible to determine a minimum amount of excavation required to create wetland hydrology in the compensation area based on water levels measured in unit C, deeper excavation to ensure a certain depth of standing surface water each year may be prudent. Deeper excavation would more closely approximate the wetter conditions in the sedge meadow where lake sedge *(Carex lacustris)* occurs, rather than the transition area between the sedge meadow and the compensation area where tussock sedge *(Carex stricta)* occurs. Therefore, it may be necessary to excavate in places to depths similar to but not below those in the sedge meadow, or to approximately 97.00 to 97.25 m after the topsoil has been replaced. This elevation could be reached in the deeper parts of the compensation area. This would involve excavation of about 0.50 to 0.75 m in the main body of the compensation area. The extent of excavation to this elevation would depend on the acreage required and the desired angle of the side slopes.

Land surface rises steeply to the east, so that inclusion of area near borings 1 and 6 may be

impractical. The deeper excavation there would require large areas to create appropriate side slopes.

A buffer strip approximately 10 m wide should be included between the excavation in the compensation area and the southern extent of the sedge meadow. The usual design criteria regarding gentle side slopes, silt fencing, and topsoil stockpiling and replacement should also be included. Excavation should only be performed in dry or frozen conditions to minimize compaction and siltation, and should be done with excavators equipped with tread specifically designed to minimize compaction.

SUMMARY

The hydrogeology of the Van Patten Woods potential wetland compensation site and adjacent sedge meadow has been characterized. The compensation site and the adjacent sedge meadow to the north are largely underlain by thin clayey silt and muck deposits. Below these deposits, a north-south trending sand and gravel body (unit C) is present beneath the wetland and the compensation site. At land surface adjacent to the sedge meadow and the compensation site, glacial till (unit B) is present to the east and a bedded silt (unit A) is present to the west.

Ground water flows through the compensation site and the sedge meadow generally westward for much of the year. Ground water discharges from unit B into unit C from the east and southeast, then flows to the northwest, where it discharges into unit A and then the Des Plaines River. During spring, water flows northeastward into unit C from unit A as well, then northward in the sedge meadow toward a small stream that drains into the Des Plaines River.

Wetland hydrology was present during spring 1995 in the vicinity of wells 2S, 5S, and 8S through 12S. Heavy precipitation during spring 1995 may have extended the usual, higher spring water levels enough to cause wetland hydrology near wells that are not installed within a jurisdictional wetland, particularly wells 2S and 5S. Measurements of wetland hydrology in the compensation area in 1996 have been affected by excavation and cannot be used to document undisturbed conditions. Vegetation data indicate that the compensation site was not wetland prior to excavation.

The sedge meadow is supported by ground-water discharge, direct precipitation, and surface-water runoff. These sources saturate unit C and pond on the land surface in areas that intersect the water table. Surface water appears in the wetland in late fall to late winter and dries up during midsummer; ponded water is in hydrologic contact with ground water in unit C. No obvious relationship of inputs to precipitation were observed. Surface-water flow northward from the sedge meadow occurs above about 97.2 m in elevation.

Recommendations regarding the design of the compensation site include excavation of the site to a depth similar to but not below that of the sedge meadow (0.50 to 0.75 m), leaving an intact barrier between the sedge meadow and the compensation site, and removing and stockpiling the topsoil prior to grading for eventual replacement in the compensation area. Topographic constraints suggest that the main body of the created wetland area should not include the area near wells 1 and 6. Excavators equipped with treads that minimize compaction should be used.

ADDENDUM: 1995 CONSTRUCTION ACTIVITIES

In summer 1995, an excavation was made in the compensation area based on the preliminary recommendations submitted in the Interim Report. Spot measurements of the bottom depths in the excavation range in elevation from about 97.0 m to 97.4 m. Three additional wells

(15S through 17S) were installed in the compensation area to help determine if the area achieves wetland hydrology. In late winter through midsummer 1996, surface water covered about one third of the excavation to a depth of about 0.5 m in the deepest portion prior to drying up in midsummer. This water level fluctuation is necessary for the sedge meadow community to be established and is similar to behavior seen in the adjacent natural sedge meadow.

Unless otherwise required by IDOT, water-level monitoring will continue for a period of 5 years after construction, ending in September 2000, when a final monitoring report will be prepared regarding the hydrologic performance of the compensation site.

ACKNOWLEDGMENTS

Funding for this study was provided primarily by the Illinois Department of Transportation. Additional funding was provided by the Illinois State Geological Survey (ISGS). David Larson, Nancy Rorick, and Steven Benton of the ISGS reviewed this report. Rebecca Reid from the Department of Geology at Northern Illinois University reviewed this report and monitored the site. Philip DeMaris and Alison Meanor of ISGS also monitored the site.

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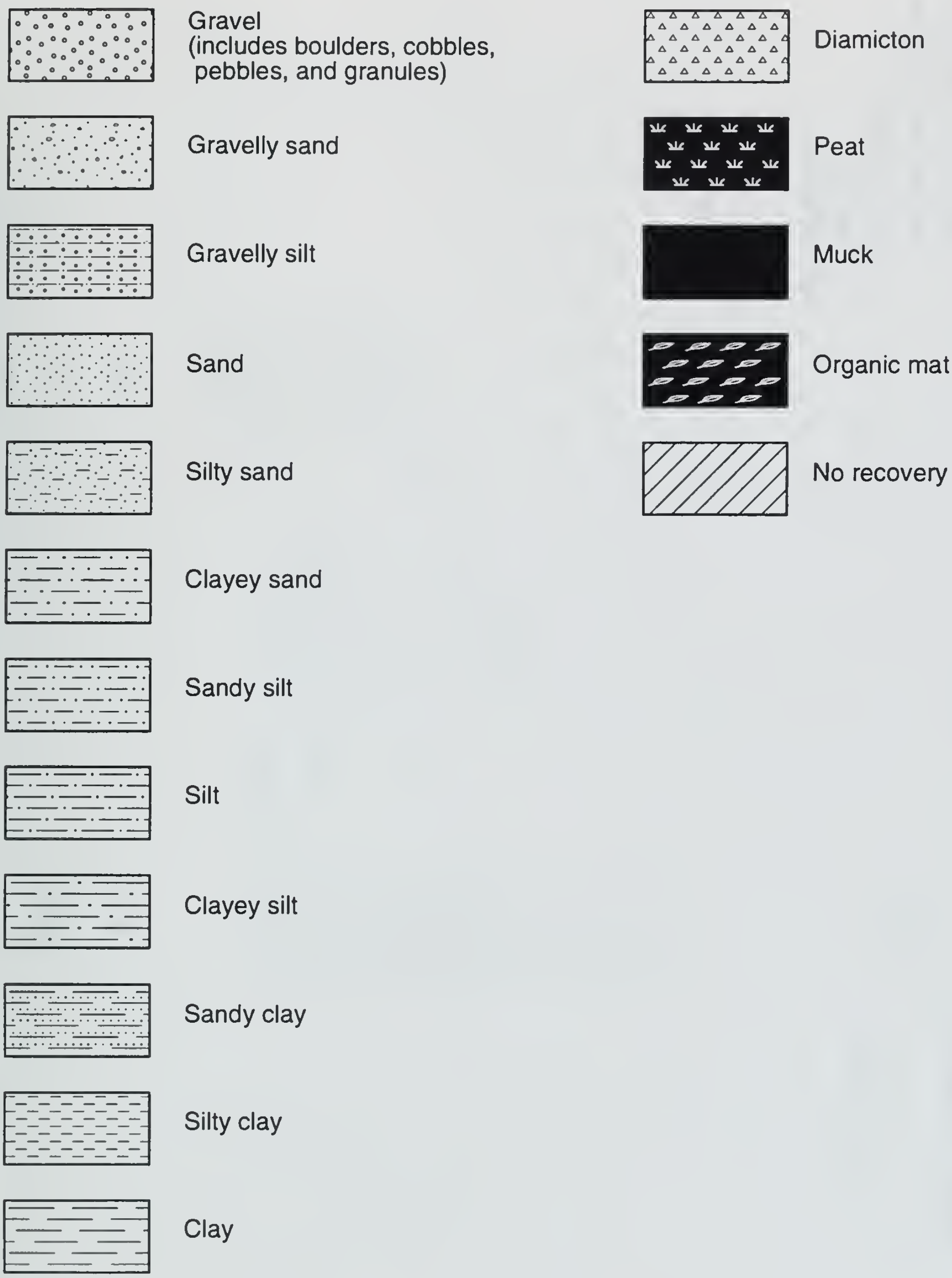
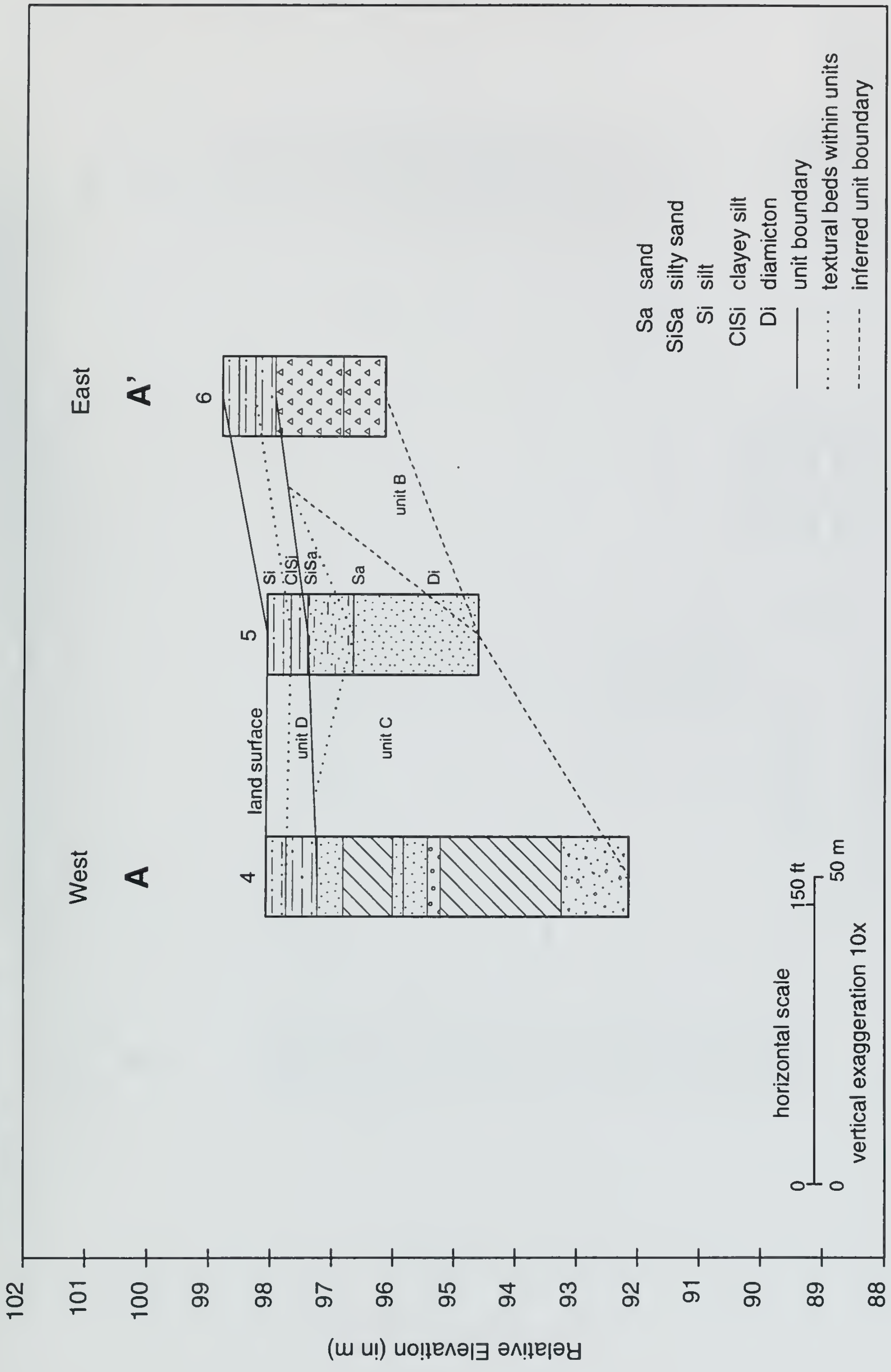
APPENDIX A Geologic Cross Sections and Logs of Borings at the Van Patten Woods Site

Part 1 Index of Geologic Symbols

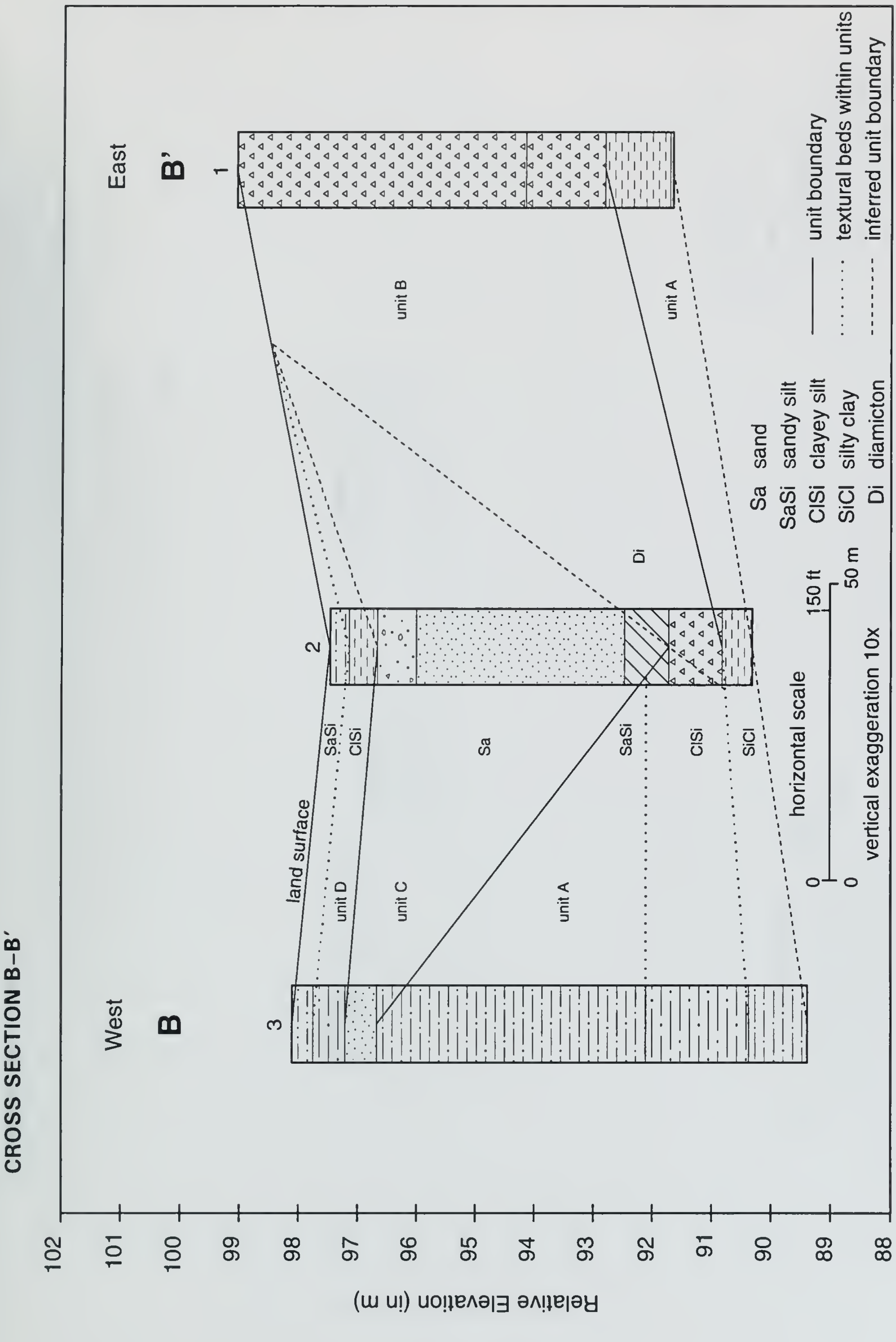


APPENDIX A Geologic Cross Sections and Logs of Borings at the Van Patten Woods Site
Part 2 Geologic Cross Sections (lines of cross section shown in figure 3)

CROSS SECTION A–A′



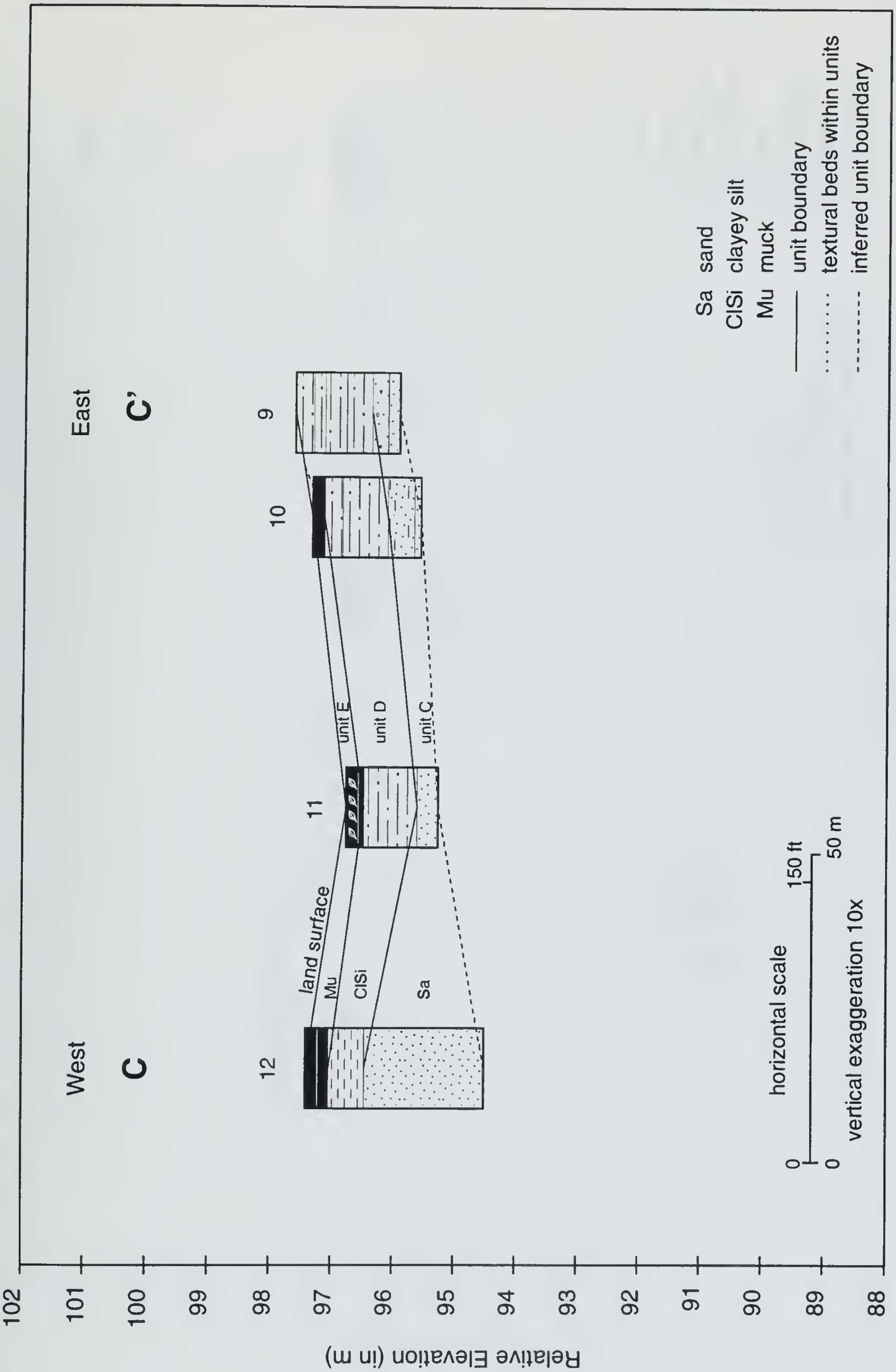
APPENDIX A *continued*
Part 2 Geologic Cross Sections (lines of cross section shown in figure 3)



APPENDIX A *continued*

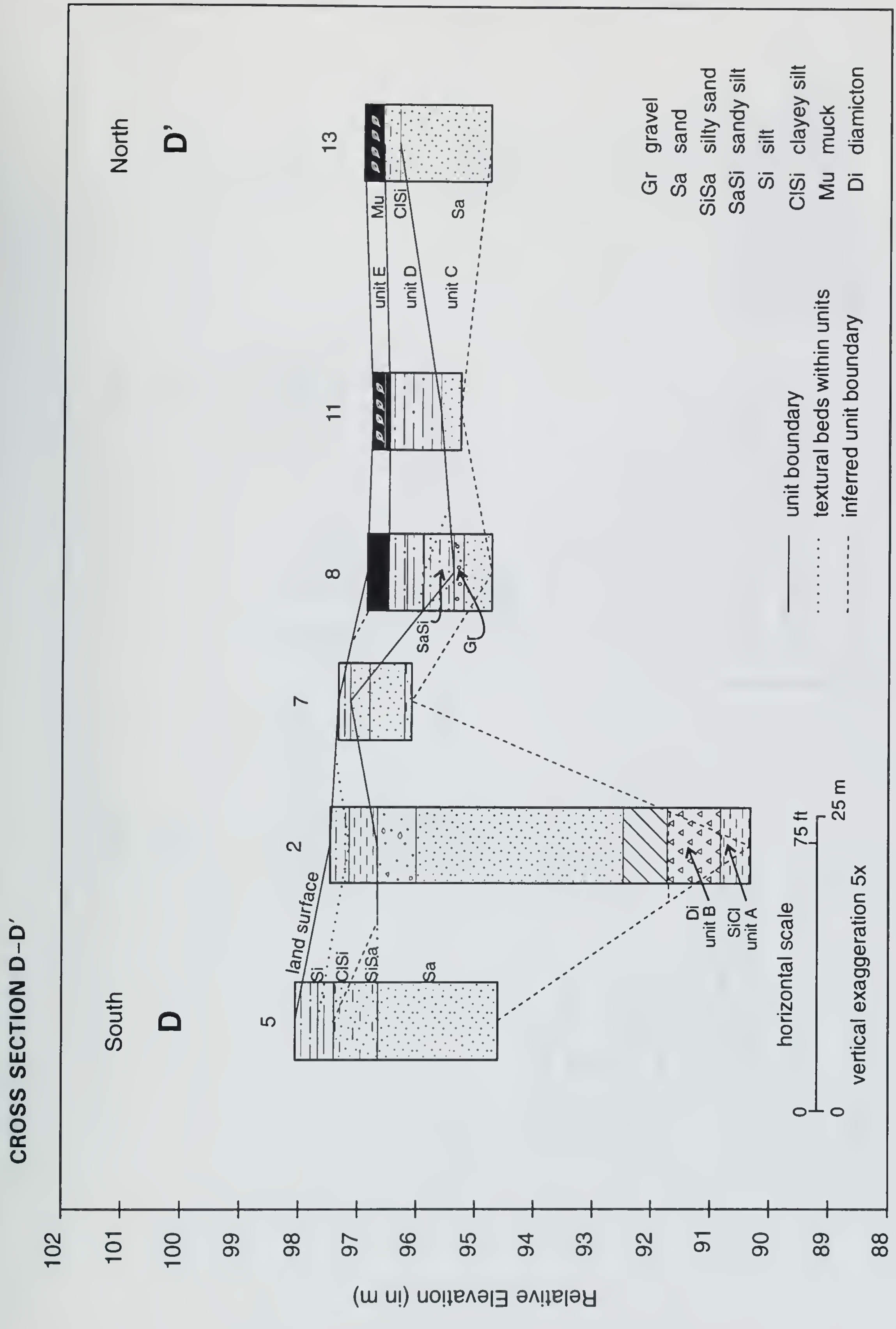
Part 2 Geologic Cross Sections (lines of cross section shown in figure 3)

CROSS SECTION C–C′

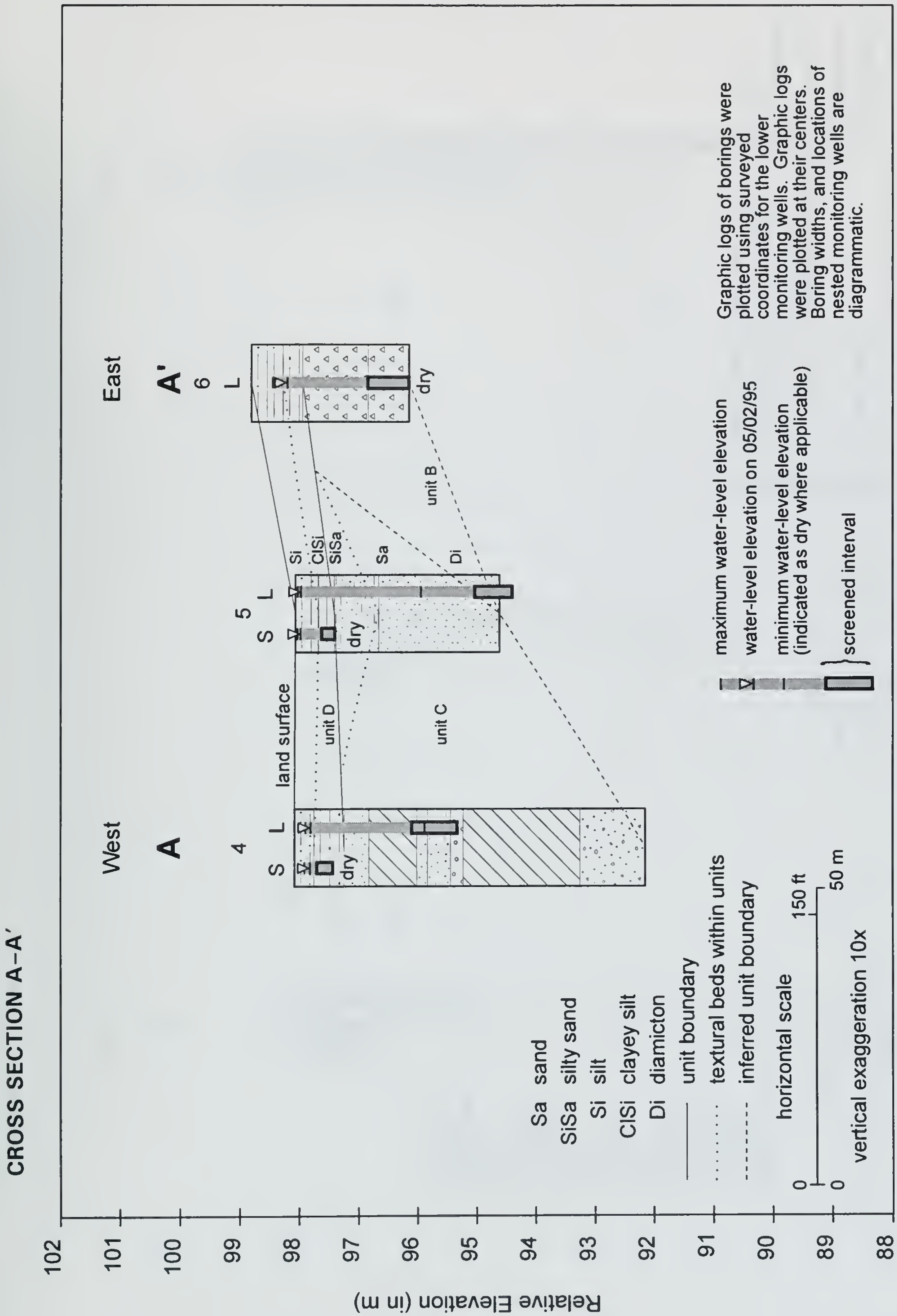


APPENDIX A *continued*

Part 2 Geologic Cross Sections (lines of cross section shown in figure 3)

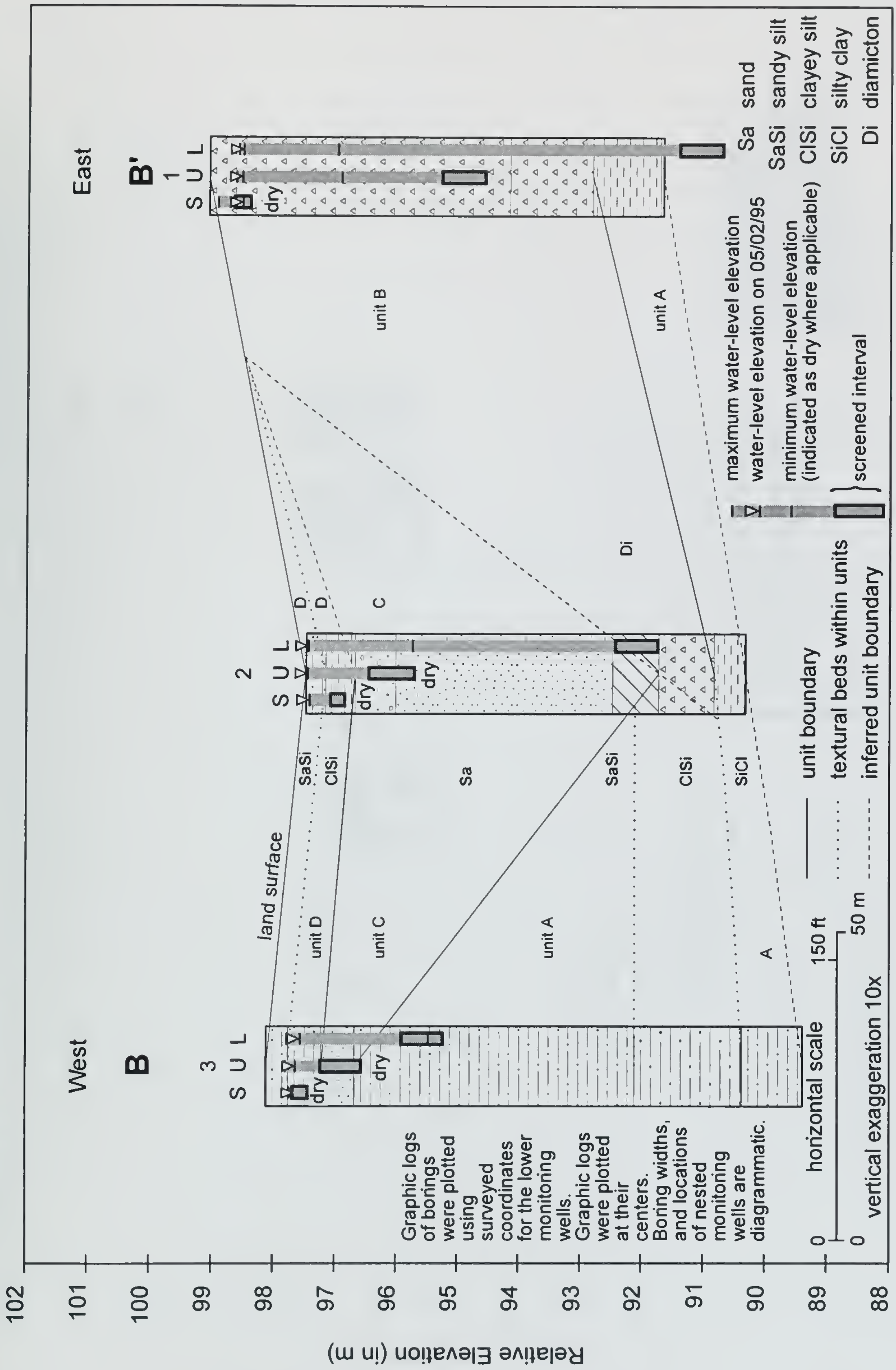


APPENDIX A **Geologic Cross Sections and Logs of Borings at the Van Patten Woods Site**
Part 3 **Cross Sections with Well Diagrams** (lines of cross section shown in figure 3)



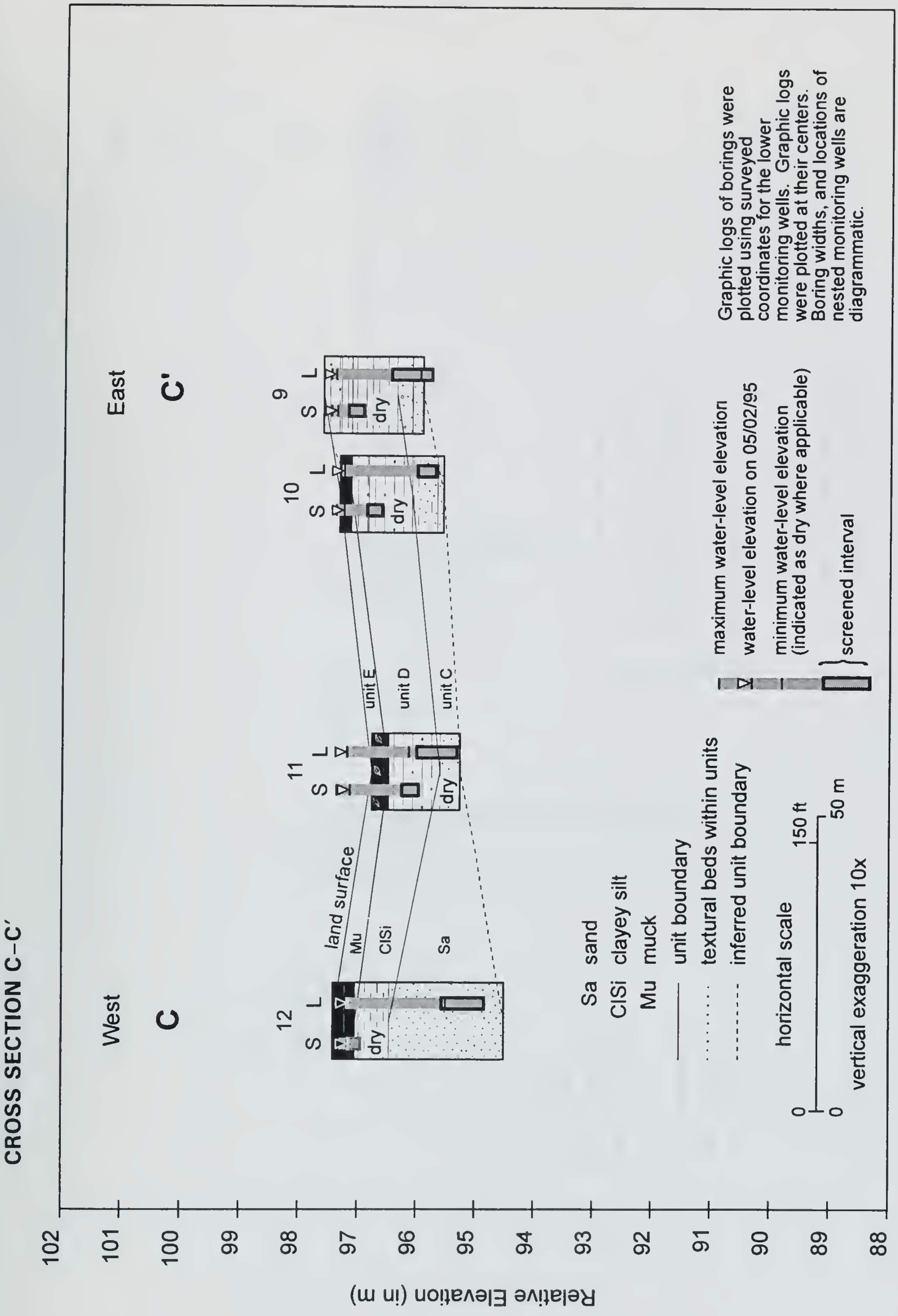
Part 3 Cross Sections with Well Diagrams (lines of cross section shown in figure 3)

CROSS SECTION B–B′



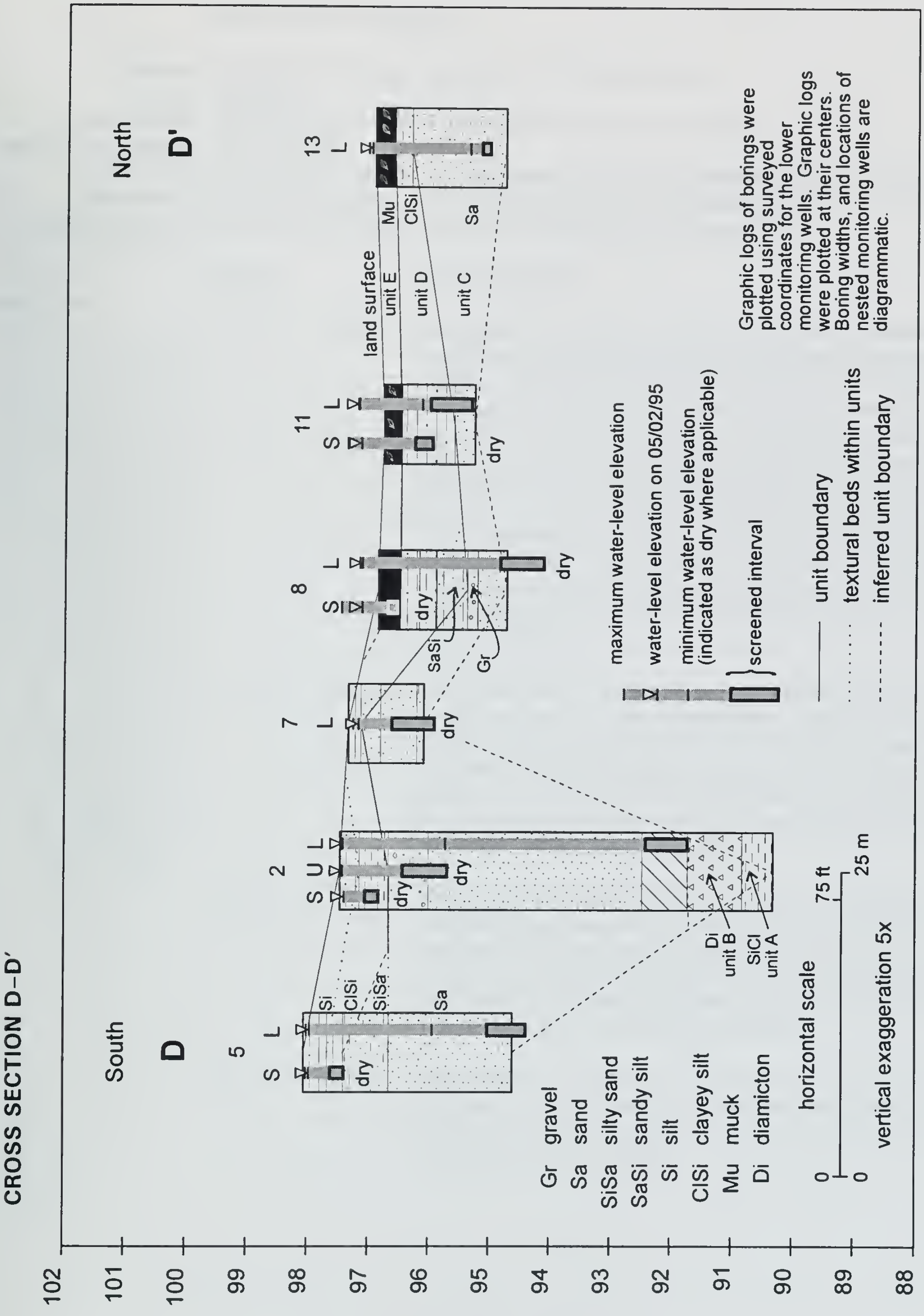
APPENDIX A *continued*

Part 3 Cross Sections with Well Diagrams (lines of cross section shown in figure 3)



APPENDIX A *continued*

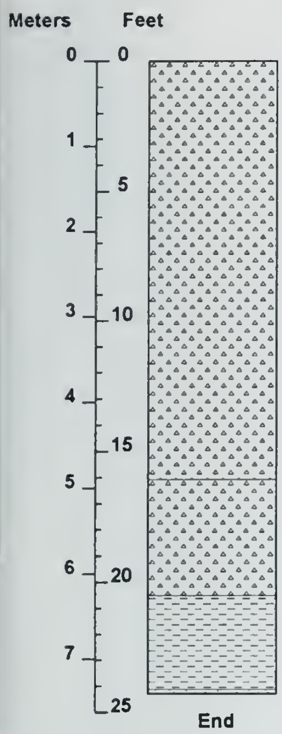
Part 3 Cross Sections with Well Diagrams (lines of cross section shown in figure 3)



APPENDIX A Geologic Cross Sections and Logs of Borings at the Van Patten Woods Site
Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #1

Location NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date 08/08/94
Field Crew Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions Not recorded
Drilled With Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments Located on upland, east of the potential wetland mitigation area
Well Information Three wells installed; construction information in Appendix C



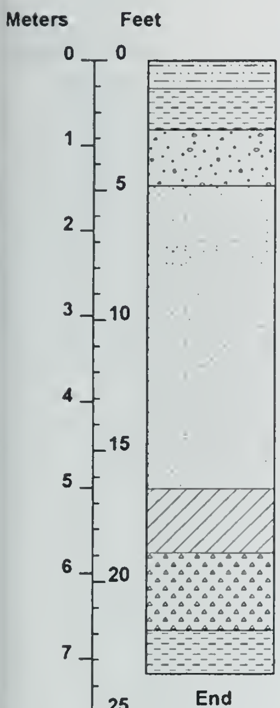
Depth		Unit Descriptions
0.00 –	4.89 m	**Diamicton;** silty clay loam texture; very stiff and dense; matrix supported; no visible sedimentary structures; less than 1% is pebbles of dolomite and red siltstone less than 10 mm in diameter; upper 0.35 m is brown (10YR 4/3), dry, noncalcareous, rooty, and has a very coarse crumb soil structure; between 0.35 and 1.52 m, grades to dark yellowish brown (10YR 4/4), is dry, weakly calcareous, and has root channels and a blocky soil structure; at 1.52 m, grades to brown (10YR 5/3) and becomes calcareous; at 2.36 m, grades to dark grayish brown (10YR 4/2) and becomes slightly softer, slightly moist, and more clay-rich; gray clay skins on fractures; at 3.45 m, grades to dark gray (10YR 4/1) and contains dark yellowish brown (10YR 4/6) fractures. Gradational lower contact to:
4.89 –	6.26 m	**Diamicton;** silty clay loam texture; moderately stiff and dense; moist; calcareous; matrix supported; contains less than 1% pebbles that are less than 10 mm in diameter of dolomite and red siltstone; slightly bedded containing softer, moister, clay-rich, grayish brown (10YR 5/2) zones in a dark gray (10YR 4/1), stiff, dry, silty clay matrix; no obvious boundaries between the beds are noted. Sharp lower contact to:
6.26 –	7.37 m	**Silty clay;** dark gray (10YR 4/1); moist; calcareous; finely laminated; Laminae are less than 1 mm thick; below 7.16 m, laminae coarsen and thicken downward; laminae consist of clay alternating with silt; clay laminae are grayish brown (10YR 5/2) and 2.5–5.0 mm thick; silt laminae are dark gray (10YR 4/1) and 1.0–2.5 mm thick. Sharp lower contact to:
7.37 –	7.41 m	**Sand;** dark gray (10YR 4/1); very coarse; sorted; clast supported; saturated; highly calcareous; bedded with sandy loam diamicton; diamicton is matrix supported, dark gray (10YR 4/1), highly calcareous, and saturated.

APPENDIX A *continued*

Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #2

Location NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date 08/08/94 3 P.M. and 08/09/94 A.M.
Field Crew Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions 70°F, overcast
Drilled With Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments Located in potential wetland mitigation area, west of boring #1
Well Information Three wells installed; construction information in Appendix C



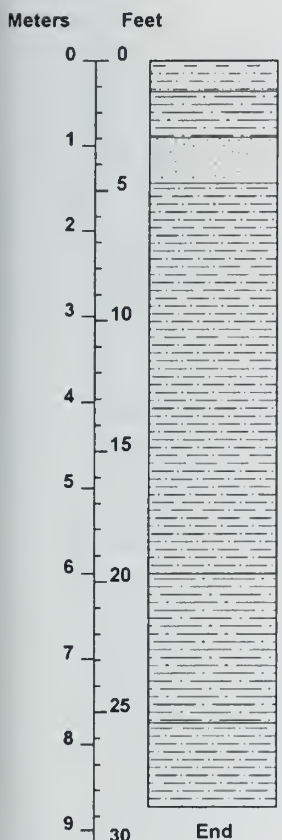
Depth	Unit Descriptions
0.00 – 0.39 m	**Sandy silt;** black (N 2.5/); dry; noncalcareous; crumb to coarse crumb structure; approximately 5–10% is sand; about 50% is roots in the upper 0.12 m. Gradational lower contact to:
0.39 – 0.81 m	**Silty clay;** dark grayish brown (2.5Y 4/2) with approximately 10% small yellowish brown (10YR 5/8) mottles; mottles increasing with depth to greater than 50% at 0.65 m; root zones have reduced colors; increased sand content with depth; approximately 10% is manganese nodules, 1.0–2.5 mm in diameter, occur in a layer between 0.70 and 0.75 m. Sharp lower contact to:
0.81 – 1.49 m	**Gravelly sand;** mixed colors of gray, white and brown; approximately 5% is silty clay; moist to wet; clast supported in sorted beds; bedding is 1–2 mm thick; gravel is poorly sorted, subrounded, and composed of dolomite, granitics, quartzite, shale, and red siltstone up to 100 mm in diameter.
1.49 – 5.00 m	**Sand;** medium to very coarse; yellowish brown (10YR 5/6); sand is sorted, rounded, and composed of dolomite, quartz, basaltics, and siltstone; approximately 3% is gravel; wet; bedded; beds are 1–2 mm thick and vary in color and grain size with medium sand layers alternating with very coarse sand layers; very dark orange staining is present from 2.05–2.19 m; gravel up to 50 mm in diameter is present from 2.80–2.95 m; at 3.28 m, the unit changes to grayish brown (10YR 5/2); a silt layer, 10 mm in thickness, occurs at 3.40 m; granule layers 5 mm in thickness occur at 3.43, 3.60, and 4.52 m; grades into fine to medium sand at 4.60 m; a 100-mm diameter dolomite rock occurs at the base.
5.00 – 5.75 m	**No recovery.**
5.75 – 6.67 m	**Diamicton;** silty clay loam texture; stratified with 10- to 20-mm thick beds of alternating dark gray (10YR 4/1) and grayish brown (2.5Y 5/2); matrix supported; rare gravel, 10–20 mm in diameter, of dolomite, shale, and basaltics; dense; dry; calcareous. Sharp lower contact to:
6.67 – 7.16 m	**Silty clay;** dark gray (10YR 4/1); calcareous; moist to dry; structureless; dense.

APPENDIX A *continued*

Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #3

Location	NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date	08/09/94 P.M.
Field Crew	Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions	Overcast, 75°F
Drilled With	Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments	Located on upland, west of boring #2. Wells were set in unsampled boring located 1.5 m west of this boring.
Well Information	Three wells installed; construction information in Appendix C

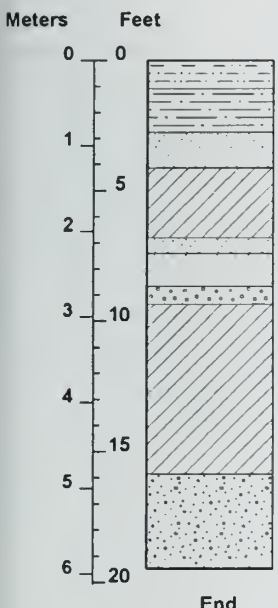


Depth	Unit Descriptions
0.00 – 0.37 m	**Sandy silt;** brown (10YR 5/3); noncalcareous; rooty; stiff; dry; approximately 5–10% is sand; structureless. Gradational lower contact to:
0.37 – 0.91 m	**Clayey silt**; brown (10YR 4/3); rooty; dry; structureless; noncalcareous; approximately 10% is sand; color change at 0.75 m to yellowish brown (10YR 5/6). Sharp lower contact to:
0.91 – 1.44 m	**Sand;** medium; grayish brown (10YR 5/2) with yellowish brown (10YR 5/8) around roots; dry; bedded by grain size with beds between 1 and 5 mm in thickness. Sharp lower contact to:
1.44 – 6.00 m	**Sandy silt**; bedded; brown (10YR 5/3) but becomes saturated and grayish brown (2.5Y 5/2) below 2.38 m; beds are 1–100 mm thick; between 1.44 and 4.00 m, silt is bedded with medium to fine sand; between 4.00 and 6.00 m, silt has graded to clayey silt which is bedded with medium to fine sand; sand beds fine downward.
6.00 – 7.73 m	**Clayey silt;** bedded; dark gray (2.5Y 4/1); saturated; clayey silt is bedded with silt; silt beds are grayish brown (2.5Y 5/2); beds are 1–100 mm thick.
7.73 – 8.73 m	**Silt;** bedded; grayish brown (2.5Y 5/2); saturated; silt is bedded with clayey silt and very coarse sand; sand beds coarsen downward; beds are 1–100 mm thick; sand beds throughout unit are brown (10YR 5/3) to yellowish brown (10YR 5/8) with sorted and rounded grains; clayey silt beds are dark gray (2.5Y 4/1) and have a blocky structure.

APPENDIX A *continued*
Part 4 **Geologic Logs of Borings**

VAN PATTEN WOODS #4

Location NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date 08/10/94
Field Crew Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions Rainy, overcast, 70°F
Drilled With Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments Well set in unsampled boring made 1.5 m southeast of this boring
Well Information Two wells installed; construction information in Appendix C

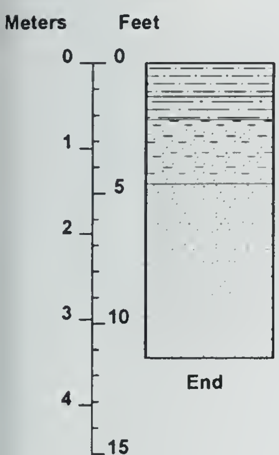


Depth		Unit Descriptions
0.00 –	0.34 m	**Sandy silt;** brown (10YR 4/3) grading to 10YR 5/3 at 0.30 m; soft; dry; noncalcareous; rooty.
0.34 –	0.83 m	**Clayey silt;** dark grayish brown (10YR 4/2); approximately 10% is sand; matrix supported; noncalcareous; porous; structureless; approximately 1–3% is gravel up to 20 mm in diameter consisting of basaltics and chert; rooty; manganese nodules noted; some mottling to yellowish brown (10YR 5/8); friable; worm burrows noted.
0.83 –	1.27 m	**Sand;** medium; laminated; laminae are 1–5 mm thick; sorted; subangular to rounded grains; noncalcareous; moist; rare 10-mm diameter gravel; clast supported.
1.27 –	2.06 m	**No recovery.**
2.06 –	2.25 m	**Sand;** medium to coarse; light yellowish brown (2.5Y 6/4); laminated by grain size with layers between 5 and 10 mm; approximately 5% is gravel up to 10 mm in diameter consisting of granitics, shale, and dolomite; noncalcareous; moist. Sharp lower contact to:
2.25 –	2.64 m	**Sand;** medium to coarse; well sorted; subangular; calcareous; structureless; moist. Sharp lower contact to:
2.64 –	2.84 m	**Sandy gravel;** saturated; sand is medium to coarse; subangular; poorly sorted; gravel is up to 100 mm in diameter and consists of dolomite, shale, and crystalline rocks; possible crude bedding.
2.84 –	4.84 m	**No recovery;** drilling behavior suggests gravel; sand in auger.
4.84 –	5.94 m	**Gravelly sand;** bedded with sandy to clayey silt; beds are 5–30 mm thick; dark gray (10YR 4/1); silts laminated; sands poorly sorted and subangular.

APPENDIX A *continued*
Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #5

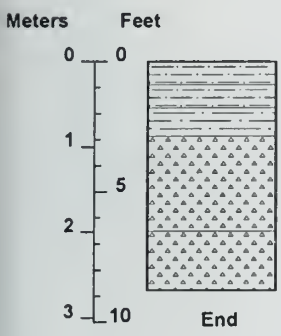
Location	NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date	08/11/94
Field Crew	Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions	Overcast, 75°F
Drilled With	Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments	Located east of boring #4, in the potential wetland mitigation area. Wells installed in unsampled boring made 1.5 m west of this boring.
Well Information	Two wells installed; construction information in Appendix C



Depth		Unit Descriptions
0.00 –	0.40 m	**Silt;** black (N 2.5/); organic; noncalcareous; dry to moist; rooty; no visible structure. Gradational lower contact to:
0.40 –	0.65 m	**Clayey silt;** olive brown (2.5Y 4/3) with yellowish brown (10YR 5/8) root rhizospheres; weakly calcareous; black burrow infillings; fine blocky peds; dry to moist. Gradational lower contact to:
0.65 –	1.40 m	**Silty sand;** moist; brown (10YR 5/3) with mottles of light olive brown (2.5Y 5/4) and yellowish brown (10YR 5/8); at 0.92 m, grades to light olive brown (2.5Y 5/4) with mottles of brown (10YR 5/3) and yellowish brown (10YR 5/8); clast supported; rare 10-mm diameter gravel consisting of dolomite, shale, and sandstone; manganese nodules present between 0.95–1.05 m. Sharp lower contact to:
1.40 –	3.45 m	**Sand;** medium to very coarse; yellowish brown (10YR 5/4); wet to saturated; poorly bedded by grain size; subrounded to subangular; sorted grains; composed of quartz, dolomite, shale, heavy minerals; rare 1-mm thick brownish silt lenses.

VAN PATTEN WOODS #6

Location	NW NE NW Section 15, T46N, R11E, Rosecrans, IL
Date	08/11/94, 3 P.M. start
Field Crew	Paul Hilchen, Jim Neal, Christine Fucciolo, James Miner
Weather Conditions	Overcast, 70°F
Drilled With	Mobile B-30S rig with a hollow-stem auger and continuous 1.5-m (5-ft) long sampler
Comments	Located in upland, east of boring #5
Well Information	One well installed; construction information in Appendix C



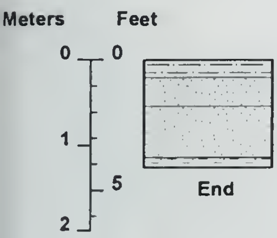
Depth		Unit Descriptions
0.00 –	0.26 m	**Silt;** very dark grey (10YR 3/1); organic; noncalcareous; rooty; dry to moist; crumb soil structure; rare 10-mm diameter dolomite gravel. Gradational lower contact to:
0.26 –	0.54 m	**Silt;** pale brown (10YR 6/3); dry; noncalcareous; coarse blocky soil structure. Gradational lower contact to:
0.54 –	0.86 m	**Clayey silt;** brown (10YR 4/3) with some root zones of strong brown (7.5YR 5/6); rooty; noncalcareous; dry; blocky soil structure; interbedded lower contact between 0.80 and 0.86 m with beds approximately 5 mm thick.
0.86 –	1.98 m	**Diamicton;** clay loam texture; dark yellowish brown (10YR 4/6); weakly calcareous; dry to moist; bedded with sand beds that are 100–200 mm thick; sand is strong brown (7.5YR 4/6), medium to very coarse, sorted, subangular, noncalcareous, dry to moist; becoming saturated, poorly sorted and poorly laminated below 1.56 m.
1.98 –	2.66 m	**Diamicton;** silty clay loam texture; dark gray (10YR 4/1) except brown (10YR 5/3) between 1.98 and 2.18 m; dense; dry to moist; large 50-mm diameter dolomite gravel at the upper contact; approximately 1% is gravel.

APPENDIX A *continued*

Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #7

Location SE SE SW Section 10, T46N, R11E, Rosecrans, IL
Date 08/22/94
Field Crew Michael Miller, James Miner
Weather Conditions Sunny 75°F, no wind
Drilled With Hand auger
Comments Located in wetland, north of the potential wetland mitigation area
Well Information One well installed; construction information in Appendix C



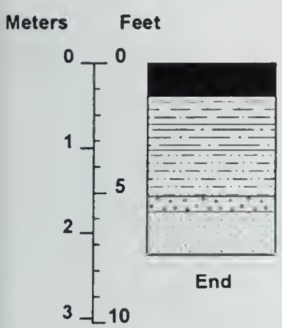
Depth		Unit Descriptions
0.00 –	0.21 m	**Silt;** black (N 2.5/); peaty structure; organic; noncalcareous; rooty; moist to dry; slight increase in clay toward base. Gradational lower contact to:
0.21 –	0.55 m	**Sand;** light olive brown (2.5Y 5/3) grading to olive gray (5Y 5/2) below 0.40 m; medium to coarse; moderately sorted; subangular; contains approximately 10% silt; matrix supported; sand contains quartz and rock fragments; mottles of yellowish red (5YR 5/8) occur below 0.25 m; dispersed pyrite crystals, approximately 1 mm in diameter, occur in layers between 0.50 and 0.55 m; noncalcareous. Gradational lower contact to:
0.55 –	1.15 m	**Sand;** grayish brown (10YR 5/2); coarse grading to very coarse toward the base; clast supported; poorly sorted and subangular grains; poorly bedded; dispersed pyrite crystals, approximately 1 mm in diameter, occur in layers between 0.55 and 0.80 m; silt laminae, 1 mm thick, occur throughout and are whitish to tan to brown in color; below 0.80 m, unit becomes saturated; rare gravel 10 mm in diameter; near the base, sand becomes very coarse, pyritic, and brownish yellow (10YR 6/8). Gradational lower contact to:
1.15 –	1.25 m	**Silty sand;** light olive brown (2.5Y 5/4); very poorly sorted; approximately 10% is gravel that is 10 mm in diameter.

APPENDIX A *continued*

Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #8

Location SE SE SW Section 10, T46N, R11E, Rosecrans, IL
Date 08/22/94
Field Crew Michael Miller, James Miner
Weather Conditions Sunny, 75°F
Drilled With Hand auger
Comments Located in wetland, north of the potential wetland mitigation area
Well Information Two wells installed; construction information in Appendix C

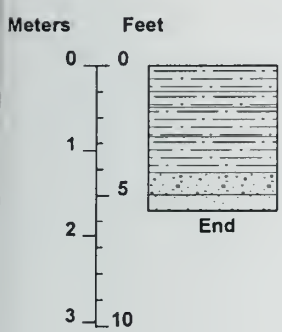


Depth		Unit Descriptions
0.00 –	0.40 m	**Muck;** root mat of partly decomposed cattails, very dark brown (10YR 2/2) becoming black (N 2.5/) at 0.09 m; slightly elastic; noncalcareous; slightly silty below 0.15 m. Sharp lower contact to:
0.40 –	0.70 m	**Silt;** black (N 2.5/) grading to dark grayish brown (2.5Y 4/2) with yellowish brown (10YR 5/8) root channels; organic; soft; roots present; slightly clayey; moist. Gradational lower contact to:
0.70 –	1.03 m	**Clayey silt;** dark grayish brown (2.5Y 4/2) with yellowish brown (10YR 5/8) root channels; soft; sticky; moist. Sharp lower contact to:
1.03 –	1.55 m	**Sandy silt;** very coarse silt and very fine sand; dark grayish brown (2.5Y 4/2); wet; clast supported. Gradational lower contact to:
1.55 –	1.75 m	**Gravel;** gray; granule-size; clean; clast supported; poorly sorted; sand composed of rock fragments and quartz; subangular; clasts up to 30 mm in diameter are present and consist of dolomite and chert; saturated.
1.75 –	2.13 m	**Sand;** gray; fine to coarse; bedded; sorted; subrounded to subangular; composed of rock fragments and quartz; saturated.

APPENDIX A *continued*
Part 4 **Geologic Logs of Borings**

VAN PATTEN WOODS #9

Location SW SW SE Section 10, T46N, R11E, Rosecrans, IL
Date 02/28/95
Field Crew James Miner, Rebecca Reid, Jeff Stillman, Martha Cardona
Weather Conditions Sunny, 25°F
Drilled With Hand auger
Comments Located north of the potential wetland mitigation site on the east side of the sedge meadow
Well Information Two wells installed; construction information in Appendix C

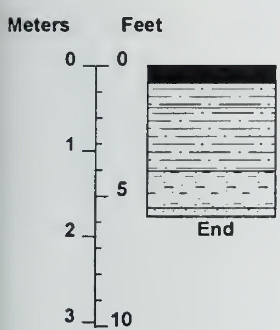


Depth		Unit Descriptions
0.00 –	0.30 m	**Clayey silt;** black (N 2.5/); moist; modern roots present; crumb soil structure; no mottling. Gradational lower contact to:
0.30 –	0.48 m	**Clayey silt;** very dark gray (10YR 3/1); moist; approximately 1–3% is sand and gravel; crumb soil structure; no apparent mottling. Gradational lower contact to:
0.48 –	0.83 m	**Clayey silt;** grayish brown (2.5Y 5/2) with yellowish brown mottles (10YR 5/8); mottles comprise about 20% and are 1–5 mm in diameter; moist; dense; approximately 1–3% is sand and gravel; rare modern roots present. Gradational lower contact to:
0.83 –	1.25 m	**Clayey silt;** olive gray (5Y 5/2) with yellowish brown (10YR 5/8) mottles; mottles comprise about 10% and are 5–10 mm in diameter. Sharp lower contact to:
1.25 –	1.51 m	**Gravelly sand;** multicolored by layers from yellowish brown to pinkish gray to orangish brown; very poorly sorted; poorly bedded; mixed matrix and clast supported; gravel is 10–30 mm in diameter, subangular and dolomitic. Gradual lower contact to:
1.51 –	1.70 m	**Sand;** grayish brown; fine to very coarse; poorly sorted; clast supported; subrounded to well rounded grains; very poorly bedded by grain size.

APPENDIX A *continued*
Part 4 **Geologic Logs of Borings**

VAN PATTEN WOODS #10

Location SW SW SE Section 10, T46N, R11E, Rosecrans, IL
Date 02/28/95
Field Crew James Miner, Rebecca Reid, Jeff Stillman, Martha Cardona
Weather Conditions Sunny, 25°F
Drilled With Hand auger
Comments Located north of the potential wetland mitigation site on the east side of the sedge meadow
Well Information Two wells installed; construction information in Appendix C



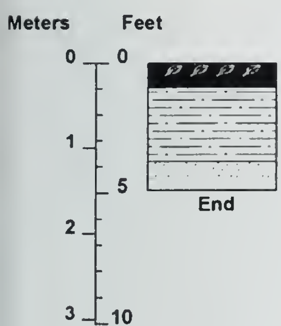
Depth	Unit Descriptions
0.00 – 0.20 m	**Muck;** black (N 2.5/); slightly elastic; rooty; approximately 30–50% is silt; very rare sand grains; massive structure. Gradual lower contact to:
0.20 – 0.49 m	**Clayey silt;** black (N 2.5/); organic-rich; rare sand grains; rooty; no mottling; very fine crumb structure. Gradual lower contact to:
0.49 – 1.23 m	**Clayey silt;** approximately 1–5% is sand; moist to saturated; between 0.49 and 0.62 m, unit is very dark gray (2.5Y 3/1), rooty, moderately stiff, and lacks mottling; between 0.62 and 1.23 m, unit contains woody fragments, and is gray (10YR 5/1) and mottled yellowish brown (10YR 5/8); mottles comprise about 25% and are approximately 1–5 mm in diameter; below 0.80 m, mottle diameter increases to 5–10 mm, and unit becomes soft and sticky.
1.23 – 1.66 m	**Silty sand;** grayish; layered; moist to saturated; matrix supported; sticky; very poorly sorted; rooty in places; multicolored pebbles of dolomite, shale, and red siltstone are present; dolomitic pebbles are up to 12 mm in diameter; subangular to angular grains. Sharp lower contact to:
1.66 – 1.77 m	**Sand;** brownish; very fine to very coarse; poorly sorted; clast supported; saturated; grains consist of quartz and rock fragments.

APPENDIX A *continued*

Part 4 Geologic Logs of Borings

VAN PATTEN WOODS #11

Location	SE SE SW Section 10, T46N, R11E, Rosecrans, IL
Date	03/01/95
Field Crew	Rebecca Reid, James Miner
Weather Conditions	Sunny, 25°F
Drilled With	Hand auger
Comments	Located north of the potential wetland mitigation site in the center of the sedge meadow
Well Information	Two wells installed; construction information in Appendix C

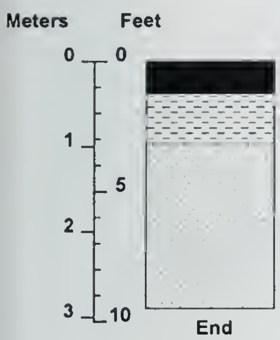


Depth		Unit Descriptions
0.00 –	0.20 m	**Organic mat** consisting of modern marsh-plant fragments; black (N 2.5/); very fibrous; no well developed peaty structure; no sand present; noncalcareous. Gradational lower contact to:
0.20 –	0.29 m	**Muck;** black (N 2.5/); clay-rich; organic; no apparent mottling or bedding; modern roots present; noncalcareous; moist. Gradational lower contact to:
0.29 –	1.16 m	**Clayey silt;** pale olive (5Y 6/4) matrix mottled with yellowish brown (10YR 5/8); mottles comprise about 30% and are 1–5 mm in diameter; noncalcareous; possibly laminated; below 0.89 m, matrix becomes pale olive (5Y 6/3) and mottles disappear. Laminated lower contact to:
1.16 –	1.50 m	**Sand;** dark gray (5Y 4/1); very poorly sorted; approximately 1–5% is gravel up to 30 mm in diameter; sand consists of quartz and rock fragments; grains are rounded to subangular and range in size from very fine to very coarse; noncalcareous; matrix supported; saturated; gravel is slightly rounded and consists of dolomite and igneous rock fragments.

APPENDIX A *continued*
Part 4 **Geologic Logs of Borings**

VAN PATTEN WOODS #12

Location SE SE SW Section 10, T46N, R11E, Rosecrans, IL
Date 03/01/95
Field Crew Rebecca Reid, James Miner
Weather Conditions Sunny, 25°F
Drilled With Hand auger
Comments Located north of the potential wetland mitigation site on the west border of the sedge meadow
Well Information Two wells installed; construction information in Appendix C

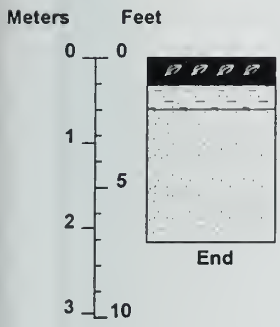


Depth		Unit Descriptions
0.00 –	0.20 m	**Muck;** black (N 2.5/); noncalcareous; modern roots present; mottling absent; coarse crumb soil structure. Gradational lower contact to:
0.20 –	0.38 m	**Muck;** black (N 2.5/); silty; noncalcareous; modern roots present; some preserved plant material present; slightly layered or streaked with light olive brown (2.5Y 5/3) silty material. Gradational lower contact to:
0.38 –	0.96 m	**Silty clay;** gray (5Y 6/1) matrix with yellowish brown (10YR 5/8) mottles; mottles comprise about 20% and are 1–5 mm in diameter; approximately 1–5% is sand. Gradational lower contact to:
0.96 –	2.91 m	**Sand;** sorted; coarsely bedded by grain size; grains range in size between fine and coarse, and are rounded to subrounded; noncalcareous; saturated; some rooty material present between 0.96 and 1.26 m; olive yellow (2.5Y 6/8) between 0.96 and 1.30 m; light olive brown (2.5Y 5/4) between 1.30 and 2.15 m; gray (10YR 5/1) between 2.15 and 2.91 m; sand consists of quartz, and rock fragments of reddish siltstone, dolomite and shale; rare shale and dolomite gravel up to 20 mm in diameter.

APPENDIX A *continued*
Part 4 **Geologic Logs of Borings**

VAN PATTEN WOODS #13

Location	SW SW SE Section 10, T46N, R11E, Rosecrans, IL
Date	03/01/95
Field Crew	Rebecca Reid, James Miner
Weather Conditions	Sunny, 25°F
Drilled With	Hand auger
Comments	Located north of the potential wetland mitigation site on the north side of the sedge meadow
Well Information	One well installed; construction information in Appendix C



Depth	**Unit Descriptions**
0.00 – 0.33 m	**Organic mat** consisting of modern plant fragments; black (N 2.5/); rooty; no peaty structure; not elastic; no apparent clastics; noncalcareous; saturated. Gradational lower contact to:
0.33 – 0.61 m	**Silty sand;** dark grayish brown (2.5Y 4/2) matrix with yellowish brown (10YR 5/8) mottles; mottles comprise about 5% and are approximately 5–10 mm in diameter; noncalcareous; saturated; sand is poorly sorted with subangular to rounded grains; sand consists of quartz and rock fragments of reddish siltstone, dolomite and shale; approximately 5–10% is clay. Gradational lower contact to:
0.61 – 2.17 m	**Sand;** grayish brown (2.5Y 5/2); sorted, noncalcareous; saturated; subangular to rounded grains; grains consist of quartz, and rock fragments of reddish siltstone, dolomite and shale; between 0.61 and 1.01 m, unit is bedded with black rooty organic layers about 5 mm thick; becomes dark gray (2.5Y 4/1) near base; some crude bedding by grain size with fine layers alternating with medium to coarse layers; occasional 20-mm diameter pebbles present.

APPENDIX B Water-Level Elevations and Depths to Water Below Land Surface

Table B1 Relative water-level elevations (in m).

Read by	ISGS	ISGS	ISGS	ISGS	ISGS	ISGS	NIU	NIU	ISGS	NIU	NIU
Date	08/31/94	10/05/94	11/02/94	11/29/94	01/05/95	02/08/95	03/05/95	03/12/95	03/15/95	03/18/95	03/26/95
Well 1S	**	**	**	**	dry	dry	dry	dry	dry	dry	dry
Well 1U	97.03	97.20	97.13	97.44	98.07	98.31	98.08	98.05	98.05	98.06	98.10
Well 1L	97.36	97.08	96.98	97.45	97.78	98.05	98.02	98.03	98.07	98.08	98.13
Well 2S	**	**	**	**	96.91	97.12	97.06	97.40	97.37	frozen	frozen
Well 2U	96.05	95.81	dry	96.70	96.89	97.11	97.09	97.41	97.38	97.32	97.29
Well 2L	96.05	95.80	95.74	96.69	96.90	97.12	97.08	97.40	97.37	97.31	97.29
Well 3S	**	**	**	**	dry	dry	dry	dry	dry	dry	dry
Well 3U	dry	dry	dry	dry	dry	96.89	96.82	96.98	97.09	97.09	96.85
Well 3L	95.76	95.53	95.47	96.03	96.48	96.78	96.72	96.91	96.99	96.98	97.22
Well 4S	**	**	**	**	dry	dry	dry	dry	dry	dry	dry
Well 4L	96.22	96.02	95.88	96.52	96.94	97.25	97.14	97.24	97.47	97.43	97.43
Well 5S	**	**	**	**	dry	dry	dry	97.56	97.62	97.55	97.55
Well 5L	96.28	96.08	95.94	96.58	*	97.35	97.24	97.55	97.59	97.55	97.55
Well 6L	dry	dry	dry	dry	97.24	97.50	97.34	97.64	97.72	97.68	97.77
Well 7L	95.99	dry	dry	96.85	96.92	97.08	97.09	97.24	97.20	97.17	97.14
Well 8S	dry	dry	dry	96.78	frozen	frozen	frozen	97.13	97.13	97.13	97.11
Well 8L	95.98	95.60	95.85	96.79	frozen	frozen	frozen	97.11	97.13	97.11	97.11
Well 9S	**	**	**	**	**	**	97.13	97.39	97.34	97.28	97.25
Well 9L	**	**	**	**	**	**	97.01	97.40	97.36	97.30	97.24
Well 10S	**	**	**	**	**	**	97.14	97.31	97.27	97.23	97.19
Well 10L	**	**	**	**	**	**	97.13	97.28	97.27	97.23	97.19
Well 11S	**	**	**	**	**	**	frozen	97.13	97.14	97.12	97.11
Well 11L	**	**	**	**	**	**	frozen	97.08	97.10	97.08	97.10
Well 12S	**	**	**	**	**	**	frozen	97.16	97.13	97.10	97.10
Well 12L	**	**	**	**	**	**	97.04	97.11	97.10	97.08	97.07
Well 13L	**	**	**	**	**	**	96.86	96.99	96.97	96.96	96.95
Gauge A	**	**	**	**	**	**	frozen	97.13	97.13	97.12	*
Gauge B	**	**	**	**	**	**	**	**	**	**	**

* no measurement
** not yet installed

APPENDIX B *continued*

Table B1 Relative water-level elevations (in m) *continued*

Read by	NIU	ISGS	NIU	NIU	NIU	NIU	ISGS	NIU	NIU	NIU	NIU
Date	04/02/95	04/05/95	04/09/95	04/15/95	04/22/95	04/29/95	05/02/95	05/06/95	05/12/95	05/19/95	05/26/95
Well 1S	98.44	dry	dry	98.67	98.63	98.84	98.52	98.59	98.62	dry	dry
Well 1U	98.19	98.21	98.22	98.33	98.44	98.51	98.53	98.53	98.53	98.52	98.42
Well 1L	98.23	98.23	98.22	98.35	98.41	98.52	98.51	98.47	98.54	98.48	98.43
Well 2S	97.33	97.29	97.42	97.40	97.41	97.13	97.41	97.41	97.42	97.32	97.37
Well 2U	97.36	97.30	97.47	97.43	97.44	97.45	97.44	97.39	97.45	97.34	97.34
Well 2L	97.35	97.30	97.44	97.43	97.42	97.46	97.43	97.39	97.45	97.33	97.26
Well 3S	dry	dry	dry	dry	dry	dry	97.64	97.47	97.61	dry	dry
Well 3U	97.22	97.17	97.16	97.45	97.47	97.80	97.63	97.47	97.62	97.35	97.42
Well 3L	97.11	97.07	97.09	97.35	97.35	97.69	97.55	97.39	97.52	97.28	97.32
Well 4S	97.59	97.53	97.66	97.77	97.77	97.91	97.81	97.72	97.84	97.67	97.58
Well 4L	97.58	97.51	97.66	97.76	97.77	97.90	97.80	97.71	97.60	97.63	97.58
Well 5S	97.75	97.66	97.73	97.96	97.96	98.03	97.97	97.83	98.00	97.76	97.70
Well 5L	97.74	97.66	97.83	97.96	97.96	98.03	97.96	97.84	98.01	97.76	97.68
Well 6L	98.05	97.89	97.92	98.34	98.28	98.45	98.19	97.96	98.32	97.86	97.90
Well 7L	97.15	97.13	97.23	97.17	97.18	97.20	97.17	97.15	97.19	97.13	97.12
Well 8S	97.12	frozen	97.13	97.13	97.13	97.14	97.12	97.13	97.14	97.13	97.17
Well 8L	97.11	frozen	97.11	97.11	97.11	97.12	97.12	97.12	97.13	97.11	97.11
Well 9S	97.26	97.24	97.33	97.35	97.33	97.49	97.38	97.29	97.43	97.26	97.26
Well 9L	97.27	97.25	97.34	97.38	97.38	97.48	97.40	97.31	97.44	97.27	97.23
Well 10S	97.21	97.19	97.26	97.25	97.13	97.29	97.26	97.21	97.27	97.19	97.19
Well 10L	97.21	97.18	97.22	97.25	97.23	97.30	97.26	97.21	97.28	97.20	97.31
Well 11S	97.25	97.12	97.16	97.13	97.14	97.15	97.14	97.12	97.14	97.13	97.12
Well 11L	97.19	97.11	97.18	97.12	97.13	97.18	97.18	97.17	97.18	97.15	97.16
Well 12S	97.10	97.11	97.13	97.12	97.13	dry	97.15	97.12	97.14	97.10	97.10
Well 12L	97.09	97.08	97.10	97.13	97.11	97.19	97.15	97.10	97.15	97.08	97.09
Well 13L	96.96	96.95	96.95	96.97	96.95	97.02	96.99	96.97	97.01	96.96	96.97
Gauge A	97.13	97.11	97.13	97.13	97.13	97.14	97.13	97.13	97.13	97.12	97.12
Gauge B	**	**	**	**	**	**	**	**	**	**	**

* no measurement

** not yet installed

APPENDIX B *continued*

Table B1 Relative water-level elevations (in m) *continued*

Read by	NIU	NIU	ISGS	NIU	NIU	NIU	NIU	ISGS	NIU	NIU	NIU
Date	06/02/95	06/10/95	06/13/95	06/21/95	06/24/95	07/05/95	07/11/95	07/11/95	07/17/95	07/24/95	07/30/95
Well 1S	dry	dry	dry	dry	*	dry	dry	dry	dry	dry	dry
Well 1U	98.37	98.26	98.22	98.09	*	97.86	97.74	97.75	97.73	97.63	97.53
Well 1L	98.40	98.30	98.25	98.11	*	97.94	97.83	97.83	97.70	97.61	97.60
Well 2S	97.20	97.37	96.96	96.79	*	dry	dry	dry	dry	dry	dry
Well 2U	97.25	97.09	96.97	96.78	*	96.67	96.55	96.55	96.45	96.34	96.25
Well 2L	97.25	97.08	96.99	96.78	*	96.67	96.54	96.55	96.43	96.34	96.26
Well 3S	dry	dry	dry	dry	*	dry	dry	dry	dry	dry	dry
Well 3U	97.21	96.98	96.89	96.67	*	dry	dry	dry	dry	dry	dry
Well 3L	97.13	96.91	96.82	96.59	*	96.39	96.29	96.30	96.20	96.10	96.03
Well 4S	97.51	dry	dry	dry	*	dry	dry	dry	dry	dry	dry
Well 4L	97.52	97.29	97.21	97.03	*	96.82	96.75	96.75	96.66	96.68	96.50
Well 5S	97.61	dry	dry	dry	*	dry	dry	dry	dry	dry	dry
Well 5L	97.61	97.36	97.30	97.14	*	96.92	96.82	96.82	96.74	96.65	96.57
Well 6L	97.71	97.46	97.38	97.22	*	97.04	96.93	96.94	*	96.77	96.70
Well 7L	97.11	97.06	96.94	96.78	*	96.74	96.47	96.50	96.37	96.22	96.16
Well 8S	97.12	97.08	97.05	96.93	*	96.78	*	*	dry	dry	dry
Well 8L	97.09	97.06	97.05	96.94	*	96.78	96.53	96.57	96.58	96.22	96.19
Well 9S	97.22	97.12	97.06	97.00	*	96.92	dry	dry	dry	dry	dry
Well 9L	97.24	97.15	97.06	96.77	*	96.71	96.55	96.56	96.43	96.27	96.21
Well 10S	97.17	97.10	97.03	96.85	*	96.73	dry	dry	dry	dry	dry
Well 10L	97.16	97.11	97.05	96.86	*	96.74	96.55	96.56	96.43	96.28	96.21
Well 11S	97.12	97.28	97.29	96.96	*	96.76	96.52	96.57	96.41	96.22	96.19
Well 11L	97.16	96.91	96.90	97.10	*	97.06	97.04	97.05	97.03	97.01	96.88
Well 12S	97.09	97.03	96.98	96.85	*	96.76	96.73	dry	dry	dry	dry
Well 12L	97.67	97.02	96.97	96.84	*	96.70	96.48	96.49	96.34	96.28	96.16
Well 13L	96.91	96.90	96.80	96.66	*	96.56	96.39	96.39	96.27	96.11	96.05
Gauge A	97.09	97.07	97.05	96.95	96.88	dry	dry	dry	dry	dry	dry
Gauge B	**	**	**	**	**	**	**	**	**	**	**

* no measurement
** not yet installed

APPENDIX B *continued*

Table B1 Relative water-level elevations (in m) *continued*

Read by	NIU	ISGS	NIU	NIU	NIU	ISGS	NIU	NIU	NIU	NIU	ISGS
Date	08/05/95	08/15/95	08/16/95	08/22/95	09/01/95	09/12/95	09/16/95	09/23/95	09/30/95	10/07/95	10/12/95
Well 1S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 1U	97.49	97.42	97.43	97.41	97.39	97.36	97.36	97.35	97.35	98.25	97.31
Well 1L	97.54	97.43	97.43	97.42	97.34	97.23	97.19	97.12	97.08	97.10	97.04
Well 2S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 2U	96.22	96.11	96.14	95.60	96.04	95.92	95.94	95.92	95.86	95.94	95.81
Well 2L	96.22	96.11	96.11	95.86	96.01	95.92	95.92	95.85	95.82	95.92	95.80
Well 3S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 3U	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 3L	95.99	95.89	95.89	95.86	95.82	95.72	95.69	95.64	95.60	95.64	95.56
Well 4S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 4L	96.45	96.36	96.36	96.31	96.26	96.18	96.16	96.10	95.82	96.06	96.02
Well 5S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 5L	96.53	96.42	96.42	96.39	96.32	96.22	96.21	96.15	96.13	96.13	96.08
Well 6L	96.68	96.65	96.65	96.65	96.62	96.61	96.62	96.59	96.60	96.59	96.58
Well 7L	96.09	96.00	95.99	96.04	dry	dry	dry	dry	dry	dry	dry
Well 8S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 8L	96.12	*	95.98	96.06	95.86	*	dry	dry	dry	dry	95.55
Well 9S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 9L	96.15	96.04	96.02	96.12	95.98	dry	95.98	dry	dry	dry	dry
Well 10S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 10L	96.13	96.03	96.08	96.03	95.91	95.77	95.72	dry	dry	dry	dry
Well 11S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 11L	96.97	96.95	96.93	96.92	96.89	96.86	96.83	96.83	96.82	96.79	*
Well 12S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 12L	96.09	95.97	95.98	96.01	95.85	95.72	95.69	95.60	95.56	95.59	95.52
Well 13L	95.96	95.86	95.88	95.85	95.75	95.57	95.58	95.48	95.48	95.40	95.38
Gauge A	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Gauge B	**	**	**	**	**	**	**	**	**	**	**

* no measurement
** not yet installed

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APPENDIX B *continued*

Table B1 Relative water-level elevations (in m) *continued*

Read by	NIU	NIU	NIU	NIU	ISGS	NIU	NIU	ISGS	NIU	ISGS	NIU
Date	10/13/95	10/21/95	11/04/95	11/11/95	11/16/95	11/18/95	11/29/95	12/06/95	12/18/95	01/10/96	01/12/96
Well 1S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 1U	97.31	97.26	97.19	96.92	*	*	97.34	97.48	97.54	97.75	97.75
Well 1L	97.05	97.07	97.16	97.26	97.34	*	97.44	97.53	97.73	97.52	97.51
Well 2S	dry	96.90	dry	dry	96.90	96.89	dry	dry	96.85	dry	dry
Well 2U	95.82	95.96	96.24	97.21	96.65	*	96.54	96.72	96.65	96.50	96.50
Well 2L	95.80	95.93	96.23	96.99	96.64	*	96.52	96.72	96.65	96.49	96.50
Well 3S	dry	dry	dry	dry	dry	97.44	dry	dry	dry	dry	dry
Well 3U	dry	dry	dry	dry	dry	*	dry	dry	dry	dry	dry
Well 3L	95.56	95.59	95.73	95.87	96.05	*	96.13	96.24	96.28	96.21	96.21
Well 4S	dry	dry	dry	dry	dry	97.65	97.65	dry	dry	dry	dry
Well 4L	96.03	96.03	96.15	96.36	96.57	*	96.58	96.75	96.71	96.59	*
Well 5S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 5L	96.07	96.10	96.19	96.59	96.59	*	96.61	96.79	96.77	96.64	96.66
Well 6L	96.59	96.57	96.62	96.55	96.73	*	96.73	97.07	96.95	96.77	96.76
Well 7L	dry	dry	96.29	96.86	96.63	96.61	96.49	96.82	96.67	96.46	96.30
Well 8S	dry	dry	dry	dry	96.64	96.64	96.66	96.78	96.70	96.59	dry
Well 8L	95.53	95.86	96.33	96.69	96.63	96.64	96.58	96.78	96.67	96.44	96.41
Well 9S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 9L	dry	dry	96.06	96.44	96.43	96.43	96.47	96.68	96.62	96.46	96.44
Well 10S	dry	dry	dry	96.73	dry	dry	dry	96.71	dry	dry	dry
Well 10L	dry	95.74	96.19	96.76	96.52	96.50	95.95	96.71	96.57	96.44	96.63
Well 11S	dry	dry	dry	96.64	96.55	96.56	96.50	96.65	96.57	96.33	frozen
Well 11L	96.84	96.81	96.78	97.00	*	96.77	96.76	*	*	*	96.15
Well 12S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 12L	95.50	95.74	96.19	96.46	96.40	96.42	96.41	96.54	96.47	96.31	96.30
Well 13L	95.38	95.52	95.98	96.44	96.34	96.32	96.29	96.45	96.50	96.23	96.18
Gauge A	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Gauge B	**	**	**	**	**	**	**	**	**	**	**

* no measurement
** not yet installed

APPENDIX B *continued*

Table B1 Relative water-level elevations (in m) *continued*

Read by	NIU	ISGS	NIU	NIU	NIU	ISGS	NIU	NIU	ISGS	NIU	NIU
Date	02/10/96	02/21/96	02/22/96	03/15/96	03/23/96	03/28/96	04/04/96	04/11/96	04/18/96	04/18/96	04/26/96
Well 1S	dry	dry	dry	dry	dry	dry	dry	dry	98.78	98.60	dry
Well 1U	97.87	97.84	97.83	97.83	97.79	97.81	97.90	97.94	98.02	98.05	98.26
Well 1L	97.68	97.69	97.67	97.78	97.79	97.84	97.89	97.90	98.00	98.02	98.09
Well 2S	96.94	96.89	96.87	97.09	96.98	97.15	97.10	97.05	97.25	97.24	97.19
Well 2U	97.04	96.85	96.86	97.13	97.03	97.15	97.12	97.06	97.25	97.25	97.18
Well 2L	96.96	96.86	96.84	97.10	97.01	97.15	97.12	97.05	97.24	97.32	97.17
Well 3S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 3U	dry	dry	dry	96.73	96.70	96.86	96.85	96.82	97.25	97.22	97.12
Well 3L	96.51	96.47	96.48	96.65	96.62	96.76	96.70	96.73	97.13	97.10	97.01
Well 4S	dry	dry	dry	dry	dry	dry	dry	dry	dry	97.47	dry
Well 4L	96.92	96.85	96.86	97.00	96.99	97.15	97.22	97.09	97.26	97.47	97.44
Well 5S	dry	frozen	dry	frozen	frozen	dry	97.40	97.13	97.61	97.61	97.54
Well 5L	97.06	96.93	96.92	97.11	97.02	97.20	97.19	97.39	97.60	97.60	97.52
Well 6L	97.16	97.03	97.01	97.20	97.15	97.40	97.27	*	98.17	98.11	97.78
Well 7L	97.00	96.82	96.84	frozen	frozen	frozen	97.16	97.17	97.23	97.24	97.16
Well 8S	96.95	frozen	frozen	97.09	97.08	97.47	97.15	97.14	97.15	97.15	97.13
Well 8L	96.95	frozen	frozen	97.07	97.03	96.82	97.14	97.14	97.17	97.15	97.12
Well 9S	dry	dry	dry	97.13	97.08	*	97.21	97.23	*	97.35	97.26
Well 9L	96.76	96.83	96.85	97.16	97.10	97.22	97.25	97.21	97.37	97.36	97.25
Well 10S	96.82	96.82	97.40	frozen	frozen	97.22	frozen	frozen	97.27	97.25	97.21
Well 10L	96.80	96.83	96.83	frozen	frozen	frozen	frozen	frozen	97.27	97.24	97.19
Well 11S	frozen	frozen	frozen	96.94	97.38	97.15	97.18	97.20	97.16	97.14	97.12
Well 11L	frozen	*	frozen	96.90	96.97	97.00	96.99	96.99	97.08	97.07	97.09
Well 12S	96.75	dry	96.72	97.00	97.29	97.11	97.10	97.10	97.16	97.15	97.11
Well 12L	96.75	96.73	96.76	96.99	96.56	97.06	97.07	97.07	97.14	97.12	97.00
Well 13L	96.47	96.52	96.54	frozen	frozen	frozen	frozen	frozen	97.00	97.06	96.97
Gauge A	dry	frozen	dry	97.09	97.08	97.15	97.15	97.14	97.15	97.15	97.12
Gauge B	**	**	**	**	**	**	**	**	**	**	**

* no measurement
** not yet installed

APPENDIX B *continued*

Table B1 Relative water-level elevations (in m) *continued*

Read by	NIU	ISGS	NIU	NIU	NIU	NIU	ISGS	NIU	NIU	ISGS	NIU	NIU
Date	05/07/96	05/16/96	05/17/96	05/25/96	05/29/96	06/08/96	06/11/96	06/22/96	07/03/96	07/09/96	07/16/96	07/28/96
Well 1S	dry	98.77	98.93	98.75	98.66	98.75	98.76	98.72	dry	dry	dry	dry
Well 1U	98.37	98.44	98.47	98.56	98.60	98.64	*	98.47	98.42	98.27	98.16	98.13
Well 1L	98.18	98.33	98.35	98.47	98.49	98.53	98.57	98.60	98.34	98.22	98.11	98.20
Well 2S	97.21	97.25	97.25	97.01	96.95	97.27	97.27	97.28	97.02	dry	96.94	97.14
Well 2U	97.22	97.25	97.27	97.25	97.24	97.27	97.27	97.27	97.02	96.80	96.94	97.15
Well 2L	97.20	97.25	97.27	97.25	97.26	97.26	97.27	97.28	97.02	96.80	96.94	97.12
Well 3S	dry	97.60	97.62	97.74	97.60	97.59	97.63	97.68	dry	dry	dry	dry
Well 3U	97.17	97.58	97.62	97.73	97.34	97.59	97.61	97.26	96.96	96.76	dry	96.87
Well 3L	97.08	97.46	97.49	97.62	97.71	97.50	97.54	97.78	96.91	96.70	96.63	96.80
Well 4S	dry	97.81	97.83	97.81	97.76	97.82	97.86	97.83	dry	dry	dry	dry
Well 4L	97.54	97.77	97.74	97.77	97.74	97.81	97.83	97.81	97.31	97.17	97.10	97.35
Well 5S	97.63	97.84	97.89	97.83	97.77	97.86	97.89	97.88	97.40	dry	dry	dry
Well 5L	97.63	97.84	97.91	97.85	97.79	97.88	97.90	97.91	97.37	97.21	97.14	97.35
Well 6L	97.85	98.33	98.48	98.37	98.23	98.38	98.40	98.38	97.46	97.30	98.10	97.38
Well 7L	97.18	97.22	97.27	97.24	97.20	97.23	97.23	97.23	97.01	96.87	96.93	97.11
Well 8S	97.12	97.14	97.14	97.13	97.14	97.15	97.14	97.13	97.03	96.99	96.94	97.06
Well 8L	97.10	97.15	97.17	97.14	97.15	97.15	97.15	97.15	97.00	97.00	96.95	97.07
Well 9S	97.27	*	97.48	97.45	97.36	97.46	97.48	97.42	97.04	dry	dry	97.05
Well 9L	97.27	97.42	97.50	97.44	97.37	97.49	97.47	97.42	97.05	96.90	dry	97.06
Well 10S	97.20	97.27	97.29	97.28	97.26	97.27	97.30	97.26	97.03	96.91	96.92	97.08
Well 10L	97.19	97.26	97.28	97.27	97.24	97.26	97.28	97.25	97.01	96.90	96.92	97.06
Well 11S	97.12	97.14	97.15	97.15	97.14	97.14	97.15	97.15	97.06	96.99	96.94	97.06
Well 11L	97.08	97.19	97.19	97.19	97.18	97.18	97.19	97.20	97.16	97.13	97.10	97.04
Well 12S	97.06	97.16	97.16	97.19	97.15	97.16	97.17	97.15	97.00	96.90	96.67	***96.12
Well 12L	97.10	97.14	97.16	97.18	97.15	97.15	97.17	97.14	97.00	96.89	97.16	***97.89
Well 13L	96.97	96.98	97.01	97.00	97.01	96.99	97.00	97.01	96.84	96.71	96.79	96.89
Gauge A	97.13	97.14	97.15	97.15	97.14	97.15	97.15	97.14	97.06	96.99	96.95	97.06
Gauge B	95.27	*	flooded	flooded	flooded	flooded	flooded	*	*	94.73	*	*

* no measurement
** not yet installed
*** probable measurement error

APPENDIX B *continued*

Table B1 Relative water-level elevations (in m) *continued*

Read by	ISGS	ISGS	NIU	ISGS	ISGS	ISGS
Date	08/23/96	09/21/96	09/29/96	10/18/96	11/15/96	12/17/96
Well 1S	dry	dry	dry	dry	dry	98.46
Well 1U	97.93	97.64	97.59	97.45	97.30	97.37
Well 1L	97.97	97.60	97.61	97.45	97.51	97.75
Well 2S	dry	dry	96.86	dry	dry	96.99
Well 2U	96.88	96.38	96.57	96.40	96.47	96.99
Well 2L	96.88	96.38	96.56	96.38	96.47	96.99
Well 3S	dry	dry	dry	dry	dry	dry
Well 3U	dry	dry	dry	dry	dry	dry
Well 3L	96.51	96.16	96.11	96.04	96.19	96.54
Well 4S	dry	dry	dry	dry	dry	dry
Well 4L	96.98	96.61	96.60	96.46	96.53	96.99
Well 5S	dry	dry	dry	dry	dry	dry
Well 5L	97.07	96.67	96.69	96.54	96.57	97.04
Well 6L	97.12	96.77	96.72	96.66	96.65	97.23
Well 7L	96.90	96.28	96.56	96.29	96.48	96.98
Well 8S	96.92	dry	dry	dry	dry	96.90
Well 8L	96.93	96.27	96.51	96.34	96.47	96.91
Well 9S	dry	dry	dry	dry	dry	dry
Well 9L	96.84	96.31	96.40	96.24	96.50	96.93
Well 10S	96.88	dry	dry	dry	*	96.92
Well 10L	96.87	96.29	96.47	96.27	96.46	96.91
Well 11S	96.92	96.24	96.47	96.32	96.46	frozen
Well 11L	97.09	96.99	96.96	96.93	96.89	96.84
Well 12S	96.83	dry	dry	dry	dry	96.80
Well 12L	96.82	96.22	96.41	96.21	96.41	96.78
Well 13L	96.74	96.21	96.43	96.27	frozen	96.73
Gauge A	96.92	dry	dry	dry	dry	96.91
Gauge B	94.59	94.59	94.48	94.73	94.39	95.05

* no measurement
** not yet installed

APPENDIX B Water-Level Elevations and Depths to Water Below Land Surface

Table B2 Depth to water in monitoring wells (in m below land surface).

Read by	ISGS	ISGS	ISGS	ISGS	ISGS	ISGS	NIU	NIU	ISGS	NIU	NIU
Date	08/31/94	10/05/94	11/02/94	11/29/94	01/05/95	02/08/95	03/05/95	03/12/95	03/15/95	03/18/95	03/26/95
Well 1S	**	**	**	**	dry	dry	dry	dry	dry	dry	dry
Well 1U	2.04	1.87	1.94	1.63	1.00	0.76	0.99	1.02	1.02	1.01	0.98
Well 1L	1.71	2.00	2.10	1.63	1.30	1.03	1.06	1.05	1.01	1.00	0.94
Well 2S	**	**	**	**	0.62	0.40	0.47	0.12	0.15	frozen	frozen
Well 2U	1.43	1.67	dry	0.78	0.59	0.37	0.39	0.07	0.11	0.16	0.20
Well 2L	1.43	1.68	1.74	0.79	0.58	0.36	0.40	0.08	0.11	0.17	0.20
Well 3S	**	**	**	**	dry	dry	dry	dry	dry	dry	dry
Well 3U	dry	dry	dry	dry	dry	1.22	1.29	1.13	1.02	1.02	1.26
Well 3L	2.33	2.56	2.62	2.06	1.61	1.31	1.36	1.18	1.10	1.11	0.87
Well 4S	**	**	**	**	dry	dry	dry	dry	dry	dry	dry
Well 4L	1.86	2.06	2.20	1.56	1.14	0.84	0.94	0.84	0.61	0.65	0.65
Well 5S	**	**	**	**	dry	dry	dry	0.51	0.45	0.51	0.51
Well 5L	1.78	1.98	2.12	1.49	*	0.71	0.82	0.51	0.47	0.52	0.51
Well 6L	dry	dry	dry	dry	1.56	1.30	1.46	1.16	1.08	1.12	1.03
Well 7L	1.35	dry	dry	0.49	0.42	0.27	0.25	0.10	0.14	0.18	0.20
Well 8S	dry	dry	dry	0.08	frozen	frozen	frozen	-0.26	-0.26	-0.26	-0.25
Well 8L	0.86	1.24	0.99	0.05	frozen	frozen	frozen	-0.28	-0.30	-0.27	-0.27
Well 9S	**	**	**	**	**	**	0.46	0.20	0.25	0.32	0.34
Well 9L	**	**	**	**	**	**	0.60	0.22	0.26	0.32	0.37
Well 10S	**	**	**	**	**	**	0.18	0.01	0.04	0.09	0.13
Well 10L	**	**	**	**	**	**	0.21	0.05	0.07	0.11	0.15
Well 11S	**	**	**	**	**	**	frozen	-0.40	-0.40	-0.39	-0.38
Well 11L	**	**	**	**	**	**	frozen	-0.31	-0.33	-0.32	-0.34
Well 12S	**	**	**	**	**	**	frozen	0.24	0.27	0.30	0.30
Well 12L	**	**	**	**	**	**	0.38	0.31	0.32	0.34	0.35
Well 13L	**	**	**	**	**	**	0.09	-0.04	-0.03	-0.01	0.00

* no measurement
** not yet installed
\- indicates water above land surface

APPENDIX B *continued*

Table B2 Depth to water in monitoring wells (in m below land surface) *continued*

Read by	NIU	ISGS	NIU	NIU	NIU	NIU	ISGS	NIU	NIU	NIU	NIU
Date	04/02/95	04/05/95	04/09/95	04/15/95	04/22/95	04/29/95	05/02/95	05/06/95	05/12/95	05/19/95	05/26/95
Well 1S	0.63	dry	dry	0.40	0.45	0.24	0.55	0.49	0.46	dry	dry
Well 1U	0.88	0.86	0.86	0.74	0.64	0.56	0.54	0.54	0.54	0.56	0.65
Well 1L	0.85	0.85	0.86	0.73	0.66	0.56	0.57	0.60	0.54	0.60	0.65
Well 2S	0.20	0.24	0.10	0.13	0.11	0.39	0.11	0.11	0.10	0.20	0.15
Well 2U	0.12	0.18	0.02	0.06	0.04	0.03	0.04	0.09	0.03	0.14	0.14
Well 2L	0.13	0.18	0.04	0.05	0.07	0.02	0.05	0.09	0.03	0.15	0.22
Well 3S	dry	dry	dry	dry	dry	dry	0.49	0.66	0.51	dry	dry
Well 3U	0.89	0.94	0.95	0.65	0.64	0.31	0.48	0.64	0.49	0.76	0.69
Well 3L	0.98	1.02	1.00	0.74	0.74	0.40	0.54	0.70	0.57	0.81	0.77
Well 4S	0.54	0.60	0.46	0.35	0.35	0.22	0.31	0.41	0.28	0.45	0.54
Well 4L	0.51	0.57	0.42	0.32	0.32	0.18	0.28	0.37	0.48	0.45	0.50
Well 5S	0.31	0.40	0.33	0.11	0.11	0.04	0.10	0.23	0.06	0.31	0.37
Well 5L	0.32	0.41	0.24	0.11	0.11	0.03	0.10	0.22	0.06	0.30	0.38
Well 6L	0.75	0.91	0.88	0.46	0.52	0.35	0.61	0.84	0.48	0.94	0.90
Well 7L	0.20	0.22	0.11	0.18	0.17	0.15	0.17	0.19	0.16	0.21	0.23
Well 8S	-0.25	frozen	-0.26	-0.26	-0.26	-0.27	-0.26	-0.26	-0.27	-0.26	-0.30
Well 8L	-0.27	frozen	-0.28	-0.28	-0.28	-0.29	-0.29	-0.28	-0.29	-0.28	-0.27
Well 9S	0.33	0.36	0.27	0.25	0.26	0.11	0.21	0.30	0.17	0.34	0.33
Well 9L	0.35	0.36	0.27	0.23	0.24	0.13	0.22	0.31	0.18	0.35	0.38
Well 10S	0.11	0.13	0.06	0.07	0.19	0.03	0.06	0.11	0.05	0.13	0.13
Well 10L	0.13	0.16	0.12	0.09	0.11	0.03	0.07	0.12	0.06	0.14	0.03
Well 11S	-0.52	-0.39	-0.42	-0.39	-0.40	-0.42	-0.40	-0.39	-0.40	-0.39	-0.39
Well 11L	-0.42	-0.35	-0.42	-0.35	-0.36	-0.41	-0.41	-0.40	-0.42	-0.39	-0.39
Well 12S	0.29	0.29	0.27	0.28	0.27	dry	0.24	0.28	0.26	0.30	0.30
Well 12L	0.33	0.34	0.32	0.29	0.31	0.23	0.27	0.32	0.27	0.34	0.33
Well 13L	-0.02	0.00	-0.01	-0.03	0.00	-0.07	-0.04	-0.03	-0.06	-0.02	-0.02

* no measurement
** not yet installed
\- indicates water above land surface

APPENDIX B *continued*

Table B2 Depth to water in monitoring wells (in m below land surface) *continued*

Read by	NIU	NIU	ISGS	NIU	NIU	NIU	NIU	ISGS	NIU	NIU	NIU
Date	06/02/95	06/10/95	06/13/95	06/21/95	06/24/95	07/05/95	07/11/95	07/11/95	07/17/95	07/24/95	07/30/95
Well 1S	dry	dry	dry	dry	*	dry	dry	dry	dry	dry	dry
Well 1U	0.71	0.81	0.85	0.98	*	1.21	1.33	1.32	1.34	1.44	1.54
Well 1L	0.68	0.78	0.83	0.97	*	1.14	1.25	1.25	1.38	1.47	1.48
Well 2S	0.32	0.16	0.56	0.74	*	dry	dry	dry	dry	dry	dry
Well 2U	0.23	0.39	0.51	0.70	*	0.82	0.94	0.94	1.04	1.14	1.23
Well 2L	0.23	0.40	0.50	0.70	*	0.81	0.94	0.93	1.05	1.14	1.22
Well 3S	dry	dry	dry	dry	*	dry	dry	dry	dry	dry	dry
Well 3U	0.90	1.13	1.22	1.44	*	dry	dry	dry	dry	dry	dry
Well 3L	0.96	1.18	1.27	1.50	*	1.70	1.80	1.79	1.89	1.99	2.05
Well 4S	0.61	dry	dry	dry	*	dry	dry	dry	dry	dry	dry
Well 4L	0.57	0.79	0.87	1.06	*	1.26	1.33	1.33	1.42	1.41	1.58
Well 5S	0.46	dry	dry	dry	*	dry	dry	dry	dry	dry	dry
Well 5L	0.45	0.70	0.76	0.92	*	1.15	1.25	1.24	1.32	1.41	1.49
Well 6L	1.09	1.34	1.42	1.58	*	1.76	1.87	1.86	*	2.03	2.09
Well 7L	0.24	0.28	0.40	0.56	*	0.61	0.87	0.85	0.98	1.13	1.19
Well 8S	-0.25	-0.21	-0.18	-0.07	*	0.08	*	*	dry	dry	dry
Well 8L	-0.25	-0.22	-0.21	-0.11	*	0.06	0.31	0.26	0.26	0.61	0.65
Well 9S	0.38	0.47	0.54	0.60	*	0.67	dry	dry	dry	dry	dry
Well 9L	0.38	0.47	0.55	0.85	*	0.91	1.07	1.06	1.19	1.35	1.40
Well 10S	0.15	0.22	0.29	0.46	*	0.59	dry	dry	dry	dry	dry
Well 10L	0.17	0.23	0.28	0.48	*	0.60	0.79	0.78	0.91	1.06	1.13
Well 11S	-0.39	-0.55	-0.55	-0.22	*	-0.03	0.22	0.17	0.33	0.52	0.54
Well 11L	-0.40	-0.14	-0.14	-0.34	*	-0.29	-0.28	-0.28	-0.26	-0.24	-0.11
Well 12S	0.31	0.37	0.42	0.55	*	0.64	0.67	dry	dry	dry	dry
Well 12L	-0.25	0.40	0.45	0.58	*	0.72	0.94	0.93	1.08	1.14	1.26
Well 13L	0.03	0.05	0.15	0.28	*	0.39	0.56	0.56	0.68	0.84	0.89

* no measurement
** not yet installed
\- indicates water above land surface

APPENDIX B *continued*

Table B2 Depth to water in monitoring wells (in m below land surface) *continued*

Read by	NIU	ISGS	NIU	NIU	NIU	ISGS	NIU	NIU	NIU	NIU	ISGS
Date	08/05/95	08/15/95	08/16/95	08/22/95	09/01/95	09/12/95	09/16/95	09/23/95	09/30/95	10/07/95	10/12/95
Well 1S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 1U	1.58	1.65	1.65	1.67	1.68	1.71	1.71	1.72	1.72	0.82	1.76
Well 1L	1.54	1.65	1.64	1.66	1.74	1.85	1.89	1.96	2.00	1.98	2.04
Well 2S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 2U	1.27	1.37	1.34	1.88	1.44	1.56	1.55	1.57	1.62	1.55	1.67
Well 2L	1.26	1.37	1.37	1.62	1.47	1.56	1.56	1.63	1.66	1.56	1.68
Well 3S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 3U	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 3L	2.10	2.20	2.20	2.23	2.27	2.37	2.39	2.44	2.49	2.45	2.52
Well 4S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 4L	1.63	1.73	1.72	1.77	1.83	1.91	1.93	1.99	2.27	2.02	2.06
Well 5S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 5L	1.53	1.64	1.65	1.67	1.74	1.84	1.85	1.91	1.93	1.93	1.98
Well 6L	2.12	2.15	2.15	2.15	2.18	2.19	2.18	2.20	2.20	2.21	2.22
Well 7L	1.25	1.35	1.35	1.31	dry	dry	dry	dry	dry	dry	dry
Well 8S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 8L	0.72	*	0.86	0.78	0.98	*	dry	dry	dry	dry	1.28
Well 9S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 9L	1.47	1.58	1.59	1.49	1.64	dry	1.64	dry	dry	dry	dry
Well 10S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 10L	1.20	1.31	1.26	1.31	1.43	1.57	1.62	dry	dry	dry	dry
Well 11S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 11L	-0.20	-0.18	-0.17	-0.16	-0.12	-0.10	-0.07	-0.07	-0.05	-0.03	*
Well 12S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 12L	1.33	1.45	1.44	1.41	1.57	1.70	1.73	1.82	1.86	1.83	1.90
Well 13L	0.99	1.08	1.07	1.10	1.20	1.38	1.37	1.46	1.46	1.55	1.57

* no measurement
** not yet installed
\- indicates water above land surface

APPENDIX B *continued*

Table B2 Depth to water in monitoring wells (in m below land surface) *continued*

Read by	NIU	NIU	NIU	NIU	ISGS	NIU	NIU	ISGS	NIU	ISGS	NIU
Date	10/13/95	10/21/95	11/04/95	11/11/95	11/16/95	11/18/95	11/29/95	12/06/95	12/18/95	01/10/96	01/12/96
Well 1S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 1U	1.76	1.81	1.89	2.15	*	*	1.74	1.59	1.53	1.32	1.32
Well 1L	2.03	2.01	1.92	1.82	1.74	*	1.63	1.55	1.35	1.56	1.57
Well 2S	dry	0.62	dry	dry	0.63	0.64	dry	dry	0.67	dry	dry
Well 2U	1.67	1.53	1.25	0.27	0.83	*	0.95	0.76	0.84	0.98	0.98
Well 2L	1.68	1.55	1.25	0.49	0.84	*	0.96	0.76	0.84	0.99	0.98
Well 3S	dry	dry	dry	dry	dry	0.69	dry	dry	dry	dry	dry
Well 3U	dry	dry	dry	dry	dry	*	dry	dry	dry	dry	dry
Well 3L	2.52	2.50	2.36	2.22	2.04	*	1.96	1.84	1.81	1.88	1.87
Well 4S	dry	dry	dry	dry	dry	0.48	0.48	dry	dry	dry	dry
Well 4L	2.05	2.05	1.93	1.72	1.51	*	1.51	1.33	1.37	1.49	*
Well 5S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 5L	1.99	1.97	1.87	1.47	1.47	*	1.45	1.28	1.29	1.42	1.41
Well 6L	2.21	2.23	2.18	2.25	2.07	*	2.07	1.73	1.85	2.03	2.04
Well 7L	dry	dry	1.06	0.49	0.72	0.73	0.85	0.53	0.68	0.89	1.05
Well 8S	dry	dry	dry	dry	0.23	0.23	0.21	0.08	0.17	0.27	dry
Well 8L	1.31	0.98	0.51	0.14	0.21	0.20	0.26	0.06	0.17	0.39	0.42
Well 9S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 9L	dry	dry	1.56	1.18	1.18	1.19	1.14	0.94	0.99	1.16	1.18
Well 10S	dry	dry	dry	0.59	dry	dry	dry	0.61	dry	dry	dry
Well 10L	dry	1.60	1.14	0.57	0.81	0.84	1.38	0.62	0.77	0.90	0.71
Well 11S	dry	dry	dry	0.09	0.18	0.18	0.23	0.08	0.17	0.41	frozen
Well 11L	-0.07	-0.05	-0.01	-0.23	*	0.00	0.01	*	*	*	0.62
Well 12S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 12L	1.92	1.68	1.23	0.96	1.02	1.00	1.01	0.88	0.95	1.11	1.12
Well 13L	1.56	1.43	0.96	0.50	0.61	0.63	0.66	0.50	0.45	0.72	0.76

* no measurement
** not yet installed
\- indicates water above land surface

APPENDIX B *continued*

Table B2 Depth to water in monitoring wells (in m below land surface) *continued*

Read by	NIU	ISGS	NIU	NIU	NIU	ISGS	NIU	NIU	ISGS	NIU	NIU
Date	02/10/96	02/21/96	02/22/96	03/15/96	03/23/96	03/28/96	04/04/96	04/11/96	04/18/96	04/18/96	04/26/96
Well 1S	dry	dry	dry	dry	dry	dry	dry	dry	0.30	0.48	dry
Well 1U	1.20	1.23	1.24	1.24	1.29	1.26	1.17	1.13	1.05	1.03	0.81
Well 1L	1.39	1.39	1.41	1.30	1.28	1.24	1.18	1.18	1.08	1.06	0.99
Well 2S	0.59	0.63	0.66	0.43	0.54	0.37	0.42	0.47	0.28	0.29	0.33
Well 2U	0.45	0.63	0.62	0.35	0.46	0.33	0.37	0.42	0.24	0.23	0.30
Well 2L	0.52	0.62	0.64	0.38	0.48	0.33	0.36	0.43	0.24	0.17	0.31
Well 3S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
Well 3U	dry	dry	dry	1.37	1.40	1.25	1.26	1.29	0.86	0.89	0.99
Well 3L	1.58	1.61	1.61	1.44	1.47	1.33	1.39	1.36	0.96	0.99	1.08
Well 4S	dry	dry	dry	dry	dry	dry	dry	dry	dry	0.65	dry
Well 4L	1.16	1.23	1.22	1.09	1.09	0.93	0.86	0.99	0.83	0.61	0.64
Well 5S	dry	frozen	dry	frozen	frozen	dry	0.67	0.93	0.45	0.46	0.53
Well 5L	1.00	1.13	1.14	0.95	1.04	0.86	0.87	0.67	0.46	0.46	0.55
Well 6L	1.64	1.77	1.79	1.59	1.65	1.40	1.53	*	0.62	0.69	1.02
Well 7L	0.35	0.52	0.51	frozen	frozen	frozen	0.18	0.17	0.11	0.11	0.19
Well 8S	-0.09	frozen	frozen	-0.23	-0.22	-0.61	-0.29	-0.28	-0.29	-0.28	-0.26
Well 8L	-0.12	frozen	frozen	-0.24	-0.19	0.02	-0.31	-0.30	-0.33	-0.31	-0.29
Well 9S	dry	dry	dry	0.47	0.51	*	0.38	0.36	*	0.24	0.33
Well 9L	0.86	0.78	0.76	0.46	0.52	0.40	0.37	0.40	0.25	0.26	0.36
Well 10S	0.50	0.50	-0.09	frozen	frozen	0.10	frozen	frozen	0.05	0.07	0.11
Well 10L	0.54	0.51	0.51	frozen	frozen	frozen	frozen	frozen	0.07	0.09	0.15
Well 11S	frozen	frozen	frozen	-0.20	-0.64	-0.42	-0.44	-0.47	-0.42	-0.40	-0.38
Well 11L	frozen	*	frozen	-0.13	-0.20	-0.24	-0.22	-0.22	-0.31	-0.30	-0.33
Well 12S	0.65	dry	0.68	0.40	0.10	0.29	0.30	0.30	0.24	0.25	0.29
Well 12L	0.67	0.69	0.66	0.43	0.86	0.36	0.35	0.35	0.28	0.30	0.42
Well 13L	0.48	0.43	0.41	frozen	frozen	frozen	frozen	frozen	-0.05	-0.12	-0.02

* no measurement
** not yet installed
\- indicates water above land surface

APPENDIX B *continued*

Table B2 Depth to water in monitoring wells (in m below land surface) *continued*

Read by	NIU	ISGS	NIU	NIU	NIU	NIU	ISGS	NIU	NIU	ISGS	NIU	NIU
Date	05/07/96	05/16/96	05/17/96	05/25/96	05/29/96	06/08/96	06/11/96	06/22/96	07/03/96	07/09/96	07/16/96	07/28/96
Well 1S	dry	0.31	0.15	0.32	0.42	0.32	0.32	0.36	dry	dry	dry	dry
Well 1U	0.70	0.63	0.60	0.51	0.47	0.44	*	0.60	0.65	0.80	0.91	0.94
Well 1L	0.90	0.75	0.73	0.61	0.59	0.55	0.51	0.48	0.73	0.86	0.97	0.88
Well 2S	0.31	0.27	0.27	0.51	0.58	0.25	0.26	0.25	0.50	dry	0.59	0.38
Well 2U	0.27	0.24	0.21	0.23	0.24	0.22	0.22	0.21	0.46	0.68	0.54	0.33
Well 2L	0.28	0.23	0.21	0.23	0.22	0.22	0.21	0.20	0.46	0.68	0.54	0.36
Well 3S	dry	0.53	0.51	0.39	0.53	0.54	0.50	0.45	dry	dry	dry	dry
Well 3U	0.94	0.53	0.49	0.37	0.77	0.52	0.50	0.85	1.15	1.35	dry	1.24
Well 3L	1.01	0.62	0.60	0.46	0.37	0.59	0.55	0.31	1.18	1.39	1.46	1.29
Well 4S	dry	0.31	0.29	0.32	0.36	0.30	0.26	0.30	dry	dry	dry	dry
Well 4L	0.54	0.31	0.34	0.31	0.34	0.28	0.25	0.27	0.77	0.91	0.99	0.73
Well 5S	0.43	0.23	0.18	0.24	0.29	0.21	0.17	0.19	0.66	dry	dry	dry
Well 5L	0.43	0.22	0.15	0.21	0.27	0.18	0.16	0.16	0.69	0.85	0.92	0.71
Well 6L	0.95	0.46	0.32	0.43	0.57	0.42	0.40	0.42	1.34	1.50	0.70	1.42
Well 7L	0.17	0.12	0.08	0.10	0.15	0.12	0.12	0.12	0.33	0.48	0.41	0.24
Well 8S	-0.25	-0.28	-0.28	-0.27	-0.28	-0.28	-0.28	-0.27	-0.16	-0.12	-0.08	-0.20
Well 8L	-0.26	-0.31	-0.33	-0.31	-0.31	-0.32	-0.31	-0.32	-0.17	-0.17	-0.11	-0.23
Well 9S	0.32	*	0.12	0.14	0.24	0.14	0.11	0.18	0.55	dry	dry	0.54
Well 9L	0.34	0.20	0.12	0.18	0.25	0.12	0.15	0.19	0.57	0.72	dry	0.56
Well 10S	0.12	0.05	0.03	0.04	0.06	0.05	0.02	0.06	0.29	0.41	0.40	0.24
Well 10L	0.14	0.07	0.06	0.07	0.09	0.08	0.05	0.09	0.32	0.44	0.42	0.28
Well 11S	-0.38	-0.41	-0.41	-0.41	-0.41	-0.41	-0.41	-0.41	-0.33	-0.25	-0.21	-0.33
Well 11L	-0.32	-0.42	-0.42	-0.42	-0.42	-0.41	-0.42	-0.44	-0.39	-0.36	-0.33	-0.28
Well 12S	0.34	0.24	0.24	0.21	0.25	0.23	0.22	0.25	0.40	0.50	0.73	***1.28
Well 12L	0.32	0.28	0.26	0.24	0.27	0.27	0.25	0.28	0.42	0.53	0.26	***-0.47
Well 13L	-0.02	-0.04	-0.06	-0.06	-0.06	-0.05	-0.05	-0.06	0.11	0.24	0.16	0.06

* no measurement
** not yet installed
*** probable measurement error
\- indicates water above land surface

APPENDIX B *continued*

Table B2 Depth to water in monitoring wells (in m below land surface) *continued*

Read by	ISGS	ISGS	NIU	ISGS	ISGS	ISGS
Date	08/23/96	09/21/96	09/29/96	10/18/96	11/15/96	12/17/96
Well 1S	dry	dry	dry	dry	dry	0.62
Well 3U	1.11	1.44	1.18	1.63	1.77	1.70
Well 1L	1.11	1.18	1.37	1.63	1.37	1.33
Well 1S	dry	dry	0.87	dry	dry	0.50
Well 2U	0.50	1.90	0.91	1.98	1.01	0.49
Well 8L	0.60	1.10	0.92	1.90	1.01	0.50
Well 3S	dry	dry	dry	dry	dry	dry
Well 3U	dry	dry	dry	dry	dry	dry
Well 3U	1.63	1.63	1.98	2.03	1.90	1.55
Well 1S	dry	dry	dry	dry	dry	dry
Well 8L	1.10	1.47	1.98	1.52	1.98	1.09
Well 5S	dry	dry	dry	dry	dry	dry
Well 8L	1.90	1.30	1.37	1.52	1.98	1.02
Well 8L	1.63	2.03	2.03	2.14	2.15	1.57
Well 7L	0.45	1.98	0.78	1.98	0.87	0.36
Well 1S	-0.05	dry	dry	dry	dry	-0.08
Well 8L	-0.10	0.56	0.33	0.50	0.36	-0.08
Well 3S	dry	dry	dry	dry	dry	dry
Well 8L	0.78	1.30	1.21	1.38	1.11	0.58
Well 10S	0.43	dry	dry	dry	*	0.41
Well 10L	0.45	1.98	0.87	1.37	0.87	0.41
Well 11S	-0.18	0.50	0.26	0.41	0.87	frozen
Well 11L	-0.33	-0.23	-0.19	-0.17	-0.18	-0.07
Well 12S	0.56	dry	dry	dry	dry	0.57
Well 12L	0.60	1.20	1.01	1.21	1.01	0.62
Well 13L	0.20	0.74	0.52	0.67	frozen	0.22

* no measurement
** not yet installed
\- indicates water above land surface

APPENDIX C Well Construction Information

Table C1 Construction information for monitoring wells (all measurements in m)

Well	Total length of well	Total depth of well	Height of measuring point above land surface	Depth to base of screen	Depth to top of screen	Depth to top of sand pack	Depth to top of bentonite seal	Depth of concrete seal
1U	5.08	4.50	0.58	4.50	3.79	3.69	0.76	0.76–surface
1L	8.98	8.38	0.60	8.38	7.67	7.22	4.72	0.76–surface
1S	1.85	0.71	1.14	0.69	0.42	0.31	surface	none
2U	2.31	1.77	0.54	1.77	1.03	0.61	0.30	0.30–surface
2L	6.79	5.75	1.04	5.75	5.05	4.40	3.35	0.30–surface
2S	1.83	0.72	1.11	0.68	0.45	0.32	surface	none
3U	2.28	1.52	0.76	1.52	0.85	0.70	0.50	0.50–surface
3L	3.77	2.86	0.91	2.86	2.18	2.03	1.55	0.50–surface
3S	1.84	0.73	1.11	0.70	0.45	0.38	surface	none
4L	3.68	2.77	0.91	2.72	1.99	1.82	0.52	0.52–surface
4S	1.83	0.72	1.11	0.69	0.42	0.35	surface	none
5L	4.83	3.73	1.10	3.67	3.03	1.68	0.53	0.53–surface
5S	1.81	0.72	1.09	0.68	0.45	0.44	surface	none
6L	3.86	2.72	1.14	2.66	1.96	1.40	0.70	0.70–surface
7L	2.35	1.50	0.85	1.42	0.72	0.60	surface	none
8S	1.78	0.36	1.42	0.32	0.16	0.10	surface	none
8L	3.88	2.79	1.09	2.72	2.00	1.25	0.40	0.40–surface
9S	1.92	0.72	1.20	0.66	0.39	0.34	surface	none
9L	2.34	1.92	0.42	1.85	1.15	1.08	surface	none
10S	1.89	0.75	1.14	0.71	0.45	0.35	surface	none
10L	2.71	1.71	1.00	1.66	1.32	1.25	surface	none
11S	1.95	0.84	1.11	0.77	0.48	0.28	surface	none
11L	2.45	1.53	0.92	1.45	0.76	0.58	surface	none
12S	1.01	0.72	0.29	0.69	0.46	0.38	surface	none
12L	3.79	2.64	1.15	2.58	1.85	1.50	surface	none
13L	3.27	1.96	1.31	1.91	1.77	1.75	surface	none